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MEASUREMENT OF ELECTRIC FIELD STRENGTH NEAR HIGHER POWERED PERSONAL TRANSCEIVERS

John Adams
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U.S. DEPARTMENT OF COMMERCE, Robert A. Mosbacher, Secretary
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, John W. Lyons, Director

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Measurement of Electric Field Strength Near Higher Powered Personal Transceivers

John Adams, Doris Wu, and Allen Budlong

Electric field strengths were measured at a number of points near 5-W personal transceivers. The points were located on cylinders of revolution around the antenna with radii of 7, 9.5, 12, 14.5, 17, and, in some cases, 27, 37, and 47 cm. At shorter distances, these measured values exceeded the exposure limits suggested in ANSI Standard C95.1-1982.

Key words: electric field measurements; personal transceivers; walkie-talkies.

1. INTRODUCTION

Law enforcement and other public safety personnel use various types of communication equipment in the performance of their day-to-day activities. Since the inception of Federal funding in the early 1970s, many law enforcement agencies have substantially increased the number of handheld personal transceivers used in their departments. A decade ago, most of these radios generated between 1 and 2 W of output power. In the past few years, however, many agencies are purchasing transceivers that produce as much as 5 or 6 W of output power as a means of improving communication range and system reliability. Unfortunately, a by-product of this enhanced capability is an increase of field strengths in the vicinity of the transceiver and its antenna.

Because of concern regarding the electromagnetic environment in which law enforcement personnel must work, the Technology Assessment Program Advisory Council recommended the initiation of a study to characterize this environment at the frequency bands used by police. The first phase of the measurement program produced a report on field strengths in vehicles with communications transmitters [1]. This effort was primarily directed toward measuring the fields produced by mobile transceivers used in vehicles. The

second phase of this effort, reported in this document, is concerned with the field strengths produced by higher powered, handheld transceivers. This report contains the results of tests conducted on typical transceivers in the four frequency bands used by the law enforcement community: 30-50, 150-174, 400-520, and 806-866 MHz. The fields were measured at distances likely to be encountered in practice.

2. FIELD STRENGTH MEASUREMENTS

2.1 Energy Sources

During this measurement series, personal transceivers were used that operated at frequencies of 40.27, 162.475, 464 and 823 MHz and with approximate output powers of 5, 5, 5, and 3 W, respectively. Electric field strengths were measured at locations described by cylinders of increasing radii with the antenna of the transceiver at the center of the cylinder.

2.2 Instrumentation

The electric field strength was measured with the multisensor, automated electric field strength measurement system described in NBSIR 86-3056 [2]. This multisensor system consists of 10 probes. Each probe has three dipoles; each dipole feeds a single channel which can be used to measure the x, y, or z components of the electric field. RF energy is converted to dc voltage by a diode detector at each dipole. Data from each channel were then stored in a file using a computer system and the software described in NBSIR 86-3056 [2]. The data were then converted into volts per meter with a calibration factor correction applied for each specific frequency. The x, y, and z components of the electric field for each probe and also the magnitude, $|E| = \sqrt{E_x^2 + E_y^2 + E_z^2}$, were recorded in units of volts per meter vs degrees of rotation of the transceiver.

A support structure shown in figure 1 held the probes in a vertical array with a separation of 10 cm between each probe. The support structure was built of nonmetallic material so as to minimize reflections. Probe #1 was at the bottom of the array while probe #10 was at the top. The complete support structure is shown in figure 2.

The probe array could be repositioned horizontally to change separation distance. It could also be repositioned vertically by 5 cm to increase the number of measurement points from 10 to 20. The vertical position is indicated by the term "offset" in some figures. Vertical adjustment was also used to obtain a common reference point for each of the personal transceivers. This reference point was determined by placing the base of the antenna on the transceiver at the same height as the probe #5. All the personal transceivers had different antenna lengths and body dimensions.

The measurements were made with the probe array held stationary at one of several separation distances while the personal transceiver was rotated in increments as shown in figure 3. Rotation was in a clockwise direction as seen from above with the 0° point on the short side of the transceiver case toward the probe array. The size of the rotation increment was a compromise between stepping speed and battery discharge rate.

In order to key the transceiver on, a pneumatic switch was improvised as shown in figure 4. It consisted of a rubber bulb taped and strapped to the push-to-talk switch. This switch was linked by a length of plastic tube to a hand-operated air pump. As the pump was actuated, the air bubble attached to the personal transceiver expanded, and turned on the transmitter. The personal transceivers were never left on for more than 45 seconds, since there was a noticeable decrease in the electric field as the battery discharged and the output stage heated. After each rotation of 360° the transceiver batteries were recharged so that each rotation had the same battery charge as the previous one.

2.3 Test Facilities

The measurements were made using either of two facilities depending on the frequency of the transceiver. For transceivers operating at 464 and 823 MHz, measurements were made in an anechoic chamber. The measurements were fully automated, since the chamber is equipped with a five-axis positioner that allowed rotation of the personal transceiver 360° in 3.6° or 7.2° steps as shown in figure 3. This allowed for 100 or 50 data points, respectively. The personal transceiver was supported above the rotator by a long fiberglass tube. The top of the tube had a wooden platform to support

the personal transceiver while the bottom was attached to the rotator. The wooden table was covered with anechoic material to reduce reflections. The probe structure was also supported by a wooden table.

Horizontal separation distances of 7, 9.5, 12, 14.5, 17, 27, 37, 47, 57 cm were used. The smaller increments at smaller separation distances were necessary to show the more rapid spatial variations in field strengths close to the transceiver. However, at the 7 and 9.5 cm distances, the side of the transceiver case would hit the array of probes between approximately 135° and 225° of rotation, so no values could be recorded within those limits (See figure 3).

For transceivers operating at 40.27 or 162.475 MHz, measurements were made on an outdoor ground screen, since the absorber in the anechoic room is not effective at these lower frequencies. The measurements on the ground screen were not automated and therefore took more time; only 16 steps of rotation could be used before the battery charge was reduced below an acceptable level. All the rotations were done by hand in 22.5° steps as shown in figure 5. The rotation was accomplished by rotating a fiberglass support tube from a tunnel under the ground screen. An additional tube was attached to the support tube to allow this rotation and to indicate the azimuth.

Because the probes were sensitive to sunlight, the probe fixture had to be wrapped in black plastic. The probes were not affected by moderate changes in temperature. At the lower frequencies fewer increments of separation distance were used, and offsets in elevation were also omitted since the spatial variations in field strength are not as rapid at the longer wavelengths. Figure 6 is a photograph of the setup in the anechoic chamber. Figure 7 is a photograph of the setup on the groundscreen.

The probes were calibrated and have an uncertainty of ±1 dB in field strength. All values reported have this as a basic uncertainty. The values measured on the ground screen, where the positioning uncertainty was ±1 cm, have the same basic uncertainty, but the values may not have been measured at exactly the position reported. At 40 MHz, this causes an additional ±4 dB uncertainty; at 162 MHz, an additional ±3 dB uncertainty. Positioning

errors in the anechoic chamber were very small, less than ±1 mm; this causes an additional ±0.25 dB uncertainty.

An operator's hand and arm may cause increase of field strengths during actual use of a transceiver over those measured when the transceiver was supported by a plastic structure. This is due to the increase in effective size of ground screen for the monopole antenna of the transceiver. This effect was about +3 to +4 dB in limited cases, but was not thoroughly investigated.

3. MEASURED DATA

For each of the transceivers measured in the anechoic chamber, 25500 data points were recorded, and from these, 8500 data points for the magnitude of E were calculated. Only 336 data points were recorded for a transceiver measured on the ground plane.

All measured values of the x, y, and z components of the electric field are available, along with calculated values of magnitude, on a DOS-formatted disk if anyone should want to calculate coupled energy based on boundary conditions. Figures 8a, 8b, and 8c illustrate this depth of detail of information. E_y is the vertical component of electric field.

The magnitude of the E field is the quantity used in the next set of figures, 9-24. The data are displayed in two-dimensional plots for each transceiver at the shortest separation, 7 cm, and at a distance of 12 cm, the shortest distance which allowed a full 360° rotation of the transceiver. The horizontal axis is the angle of rotation. The 7 cm separation shows maximum field strengths. Some problems that occurred during data gathering (such as variation due to varying battery voltage) show up in some of these figures. Vertical displacement is indicated by the term offset.

Figures 25 through 41 are three-dimensional plots in cylindrical coordinates; they show the spatial variations in field strength around the antenna of the transceiver. The radii of the disks are proportional to measured field strengths; the highest field strengths occur in the volume immediately adjacent to the transceiver antenna. There are no nulls or low field strengths in the immediate vicinity of the transceiver antenna.

4. COMPARISON OF MEASURED DATA WITH THE ANSI C95.1-1982 STANDARD AND CONCLUSIONS

It is not within the scope of this study to state what levels of electromagnetic fields constitute a health hazard. Such issues are outside the mission and expertise of the National Institute of Standards and Technology (NIST) and are the responsibility of organizations and committees that have been established to perform and interpret research on the biological effects of electromagnetic fields and to set exposure limits based on the results of such research. NIST is responsible for the accurate measurement of electromagnetic fields.

The American National Standards Institute (ANSI), together with the Institute of Electrical and Electronic Engineers (IEEE) and the US Department of the Navy, have prepared and adopted a voluntary radio frequency protection guide for the frequency bands involved in this measurement program. This guide was published as ANSI C95.1-1982, Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz [3]. It was reviewed and approved by the 35 organizations and government agencies listed on page 4 in the standard.

This ANSI standard gives limits in units of field strength squared $(V/m)^2$ for electric field strength, $(A/m)^2$ for magnetic field strength), and mW/cm^2 for power density as a function of frequency. These limits were selected to keep the specific absorption rate (SAR) below 0.40 W/kg of human tissue as averaged over the whole body and the SAR below 8 W/kg averaged over any 1 g of tissue. Values are given in table 1 and shown graphically in Figure A1 of the standard.

The presentation format that is probably of most interest to the user of these transceivers is a graph of typical measured field strengths plotted relative to the field strength limit for human exposure to radio-frequency fields as given in the ANSI C95.1-1982 Standard [3]. There are many temporal and spatial variations allowed by this standard, but these measured data show that the field strengths are clearly greater than the recommended levels. At 40 and 162 MHz, E^2 is about two orders of magnitude greater than the value specified in this standard. See figures 42 and 43.

Although the measured values of field strength from these transceivers are high relative to the exposure limits of the ANSI standard, how much energy couples into the body is not really known. What is needed is a more thorough analysis of the coupling of electromagnetic energy into a phantom of a human head, with particular emphasis on coupling into the eyes, which are usually very near the strongest fields measured, near the antenna of the transceiver. The eyes are one of the more vulnerable organs of the human body because the poor capacity of the circulatory system within the eyes is inefficient at removing heat.

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[2] W.D. Bensema, G.H. Koepke, and H.W. Medley, Handbook for Operation and Maintenance of an NBS Multisensor Automated EM Field Measurement System, NBSIR 86-3056, Oct. 1986.

[3] Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz, American National Standards Institute, ANSI C95.1-1982.

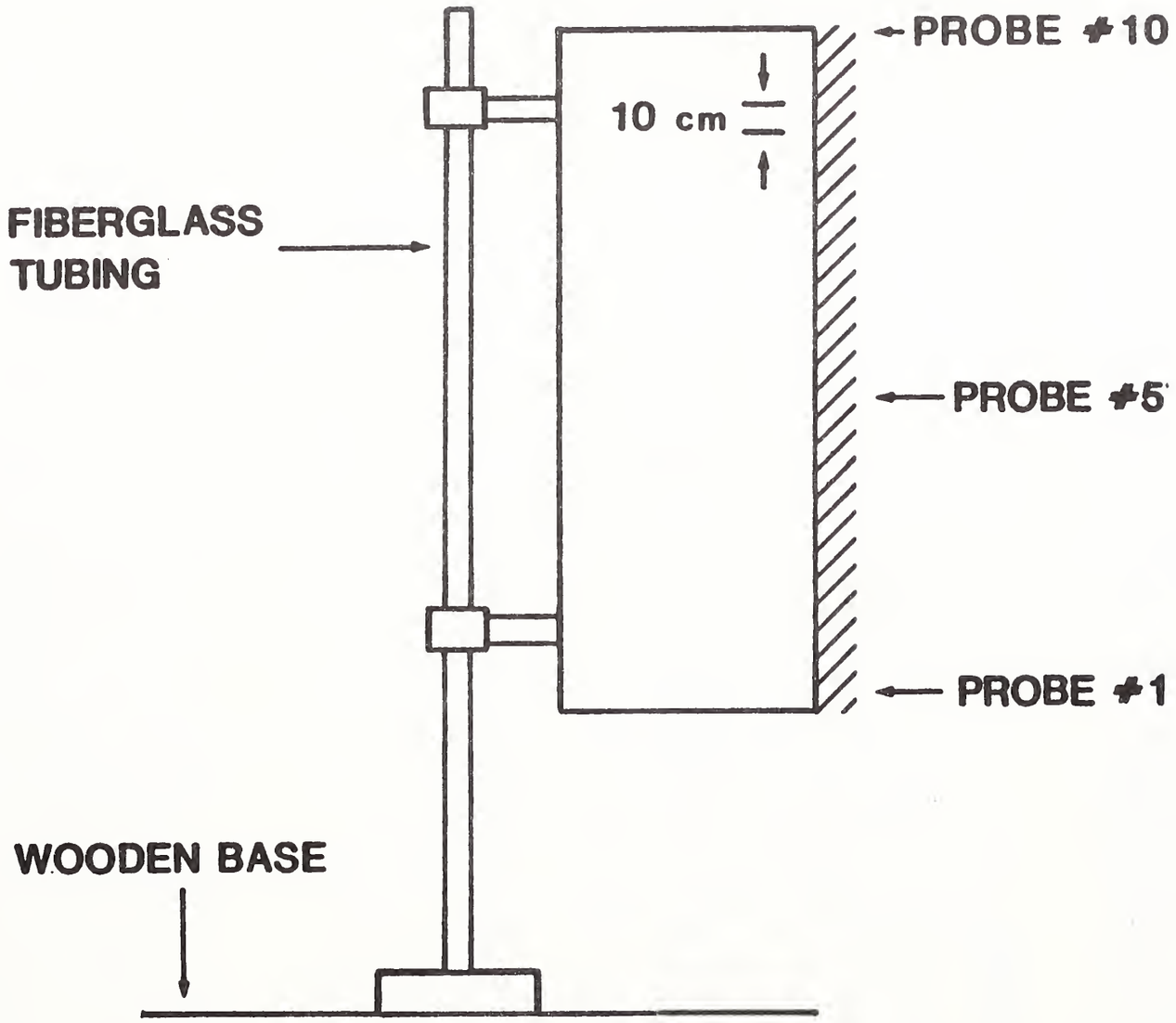

Figure 1. Non-metallic support structure for array of 10 probes.

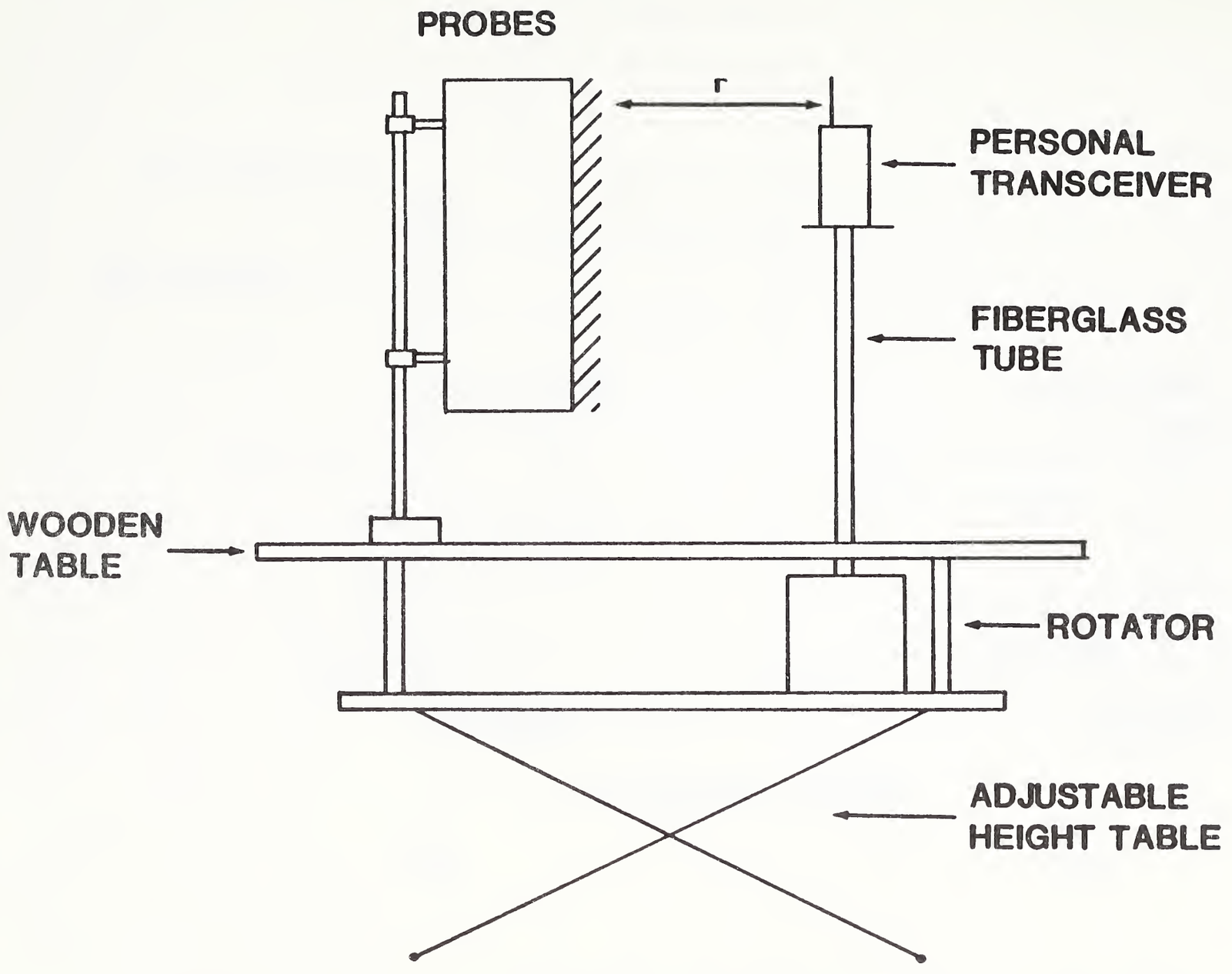

Figure 2. Complete support structure used in anechoic chamber.

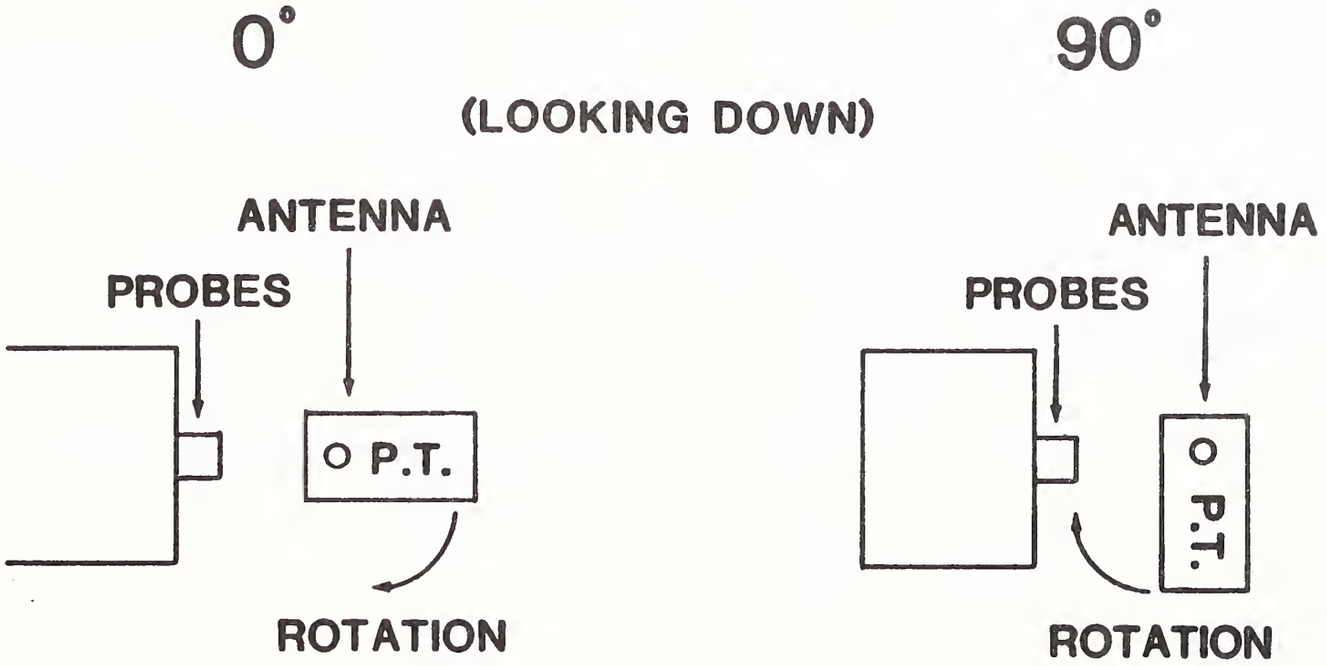

Figure 3. Rotation of personal transceivers.

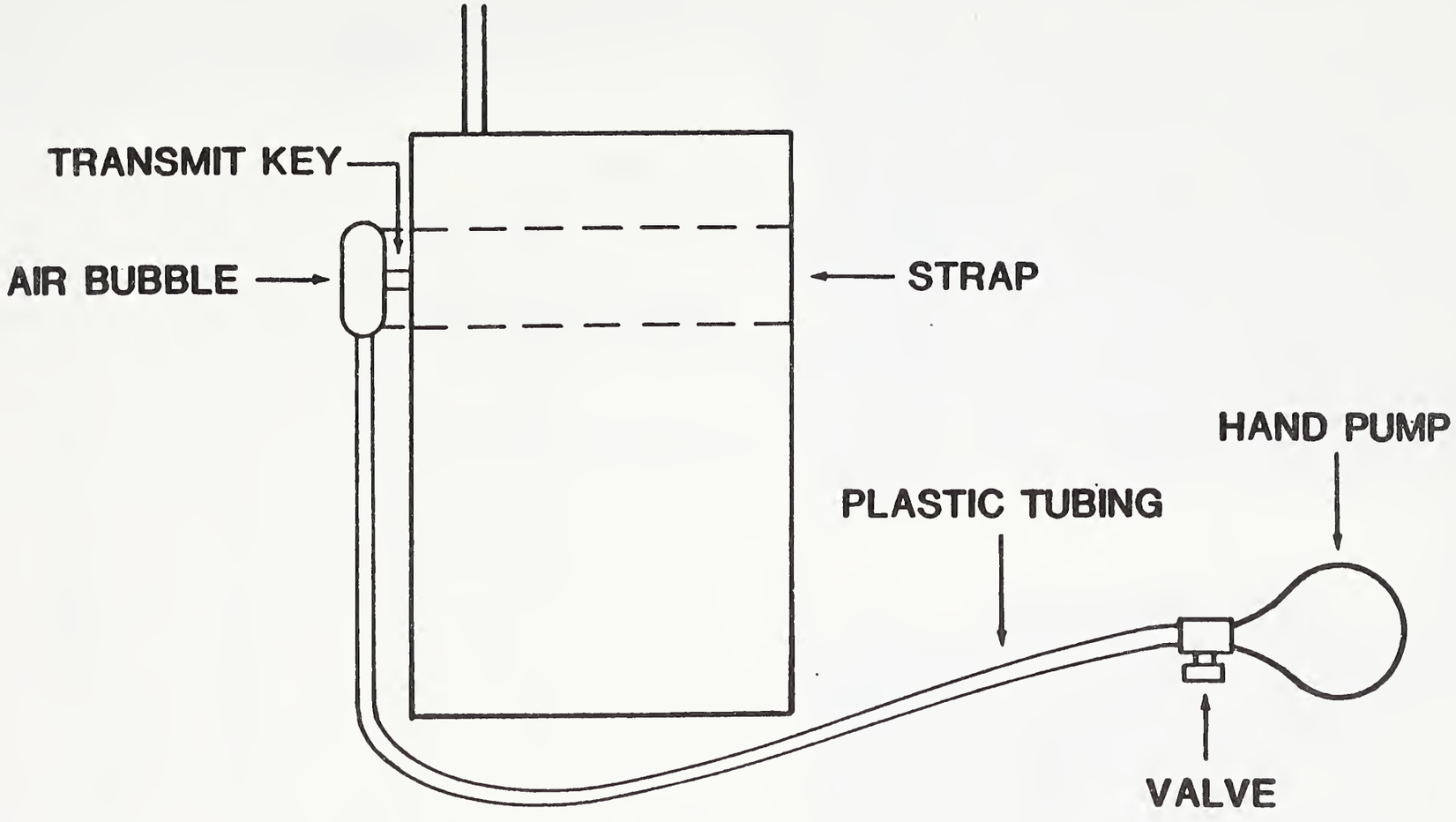

Figure 4. Illustration of method of keying transceiver using pneumatic bubble and hand pump.

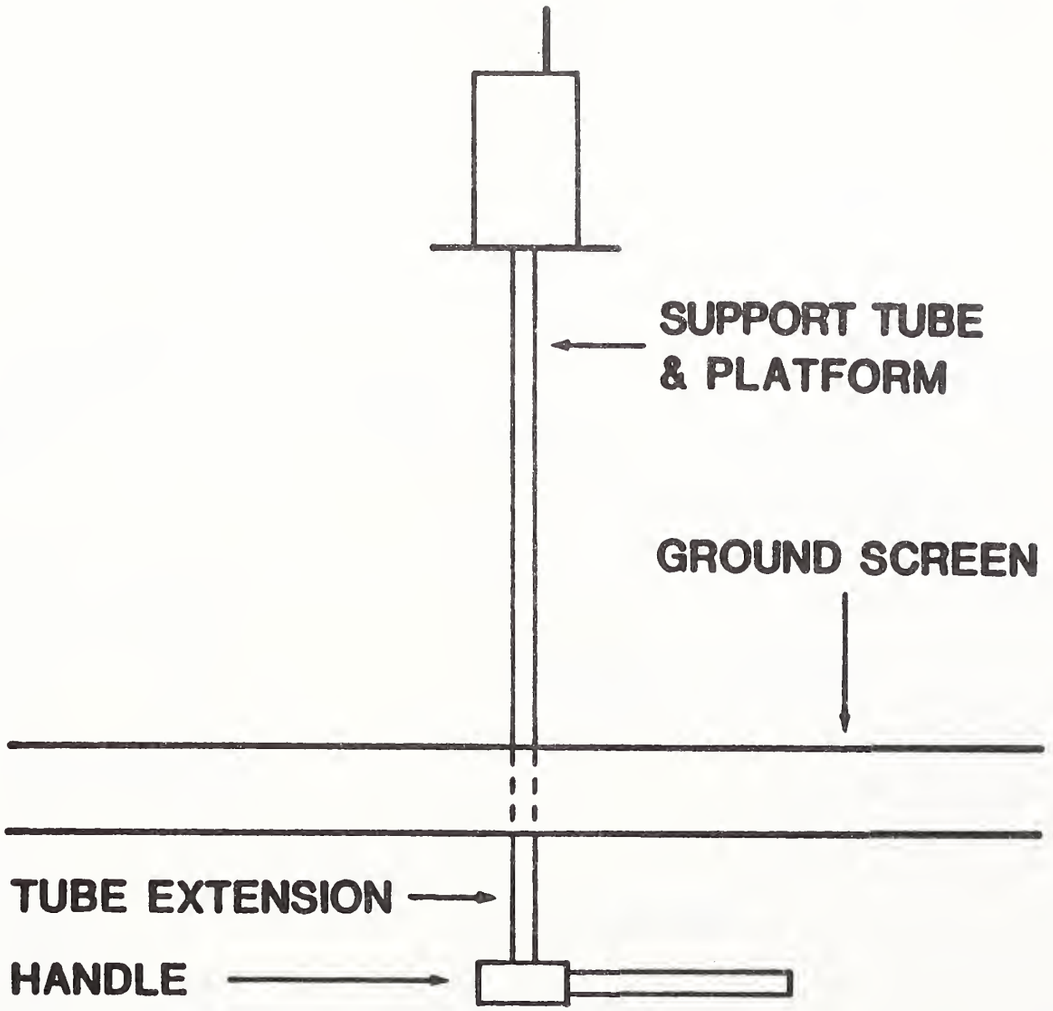

Figure 5. Setup for measurements on ground screen.

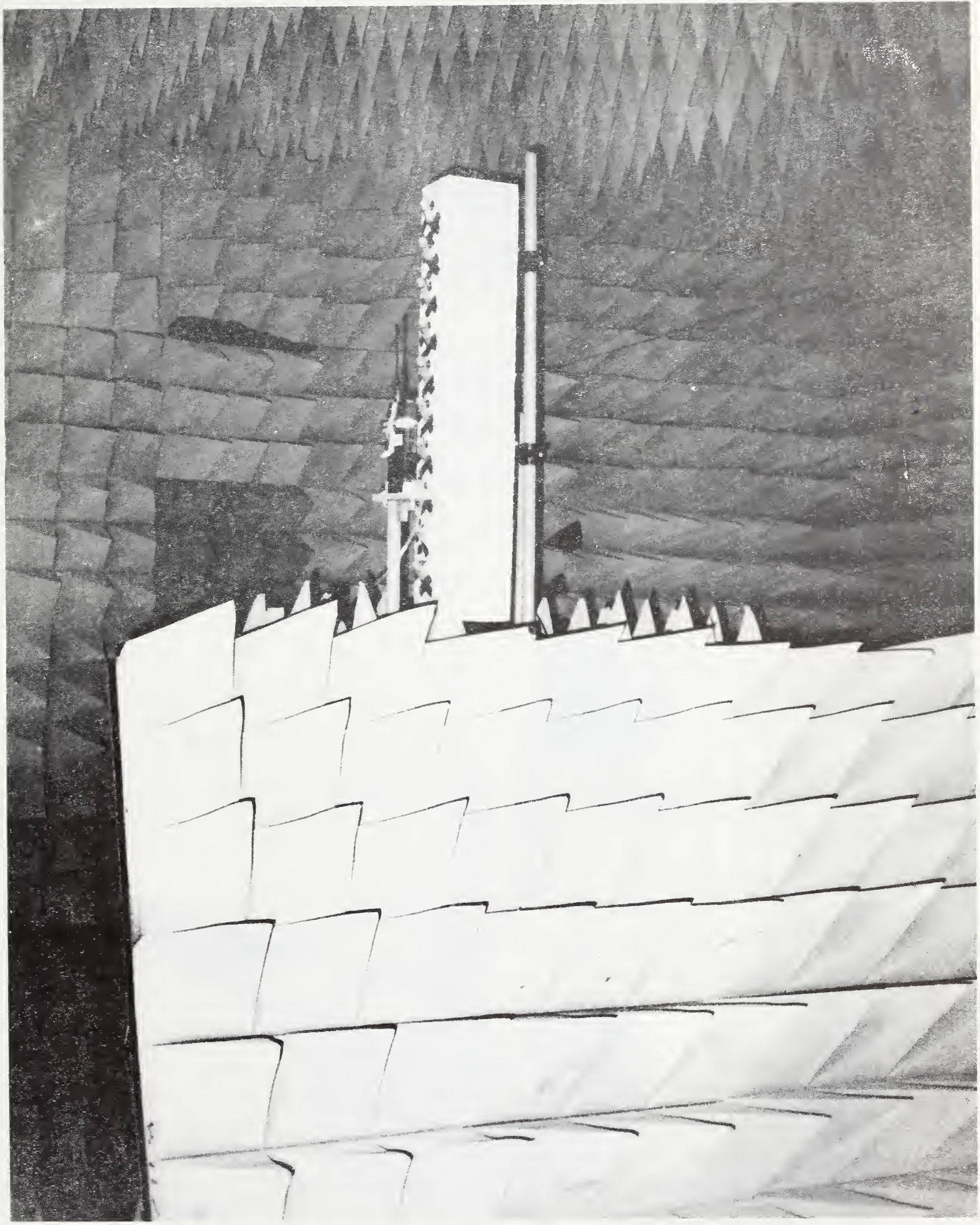

Figure 6. Picture of setup for measurements inside anechoic chamber.

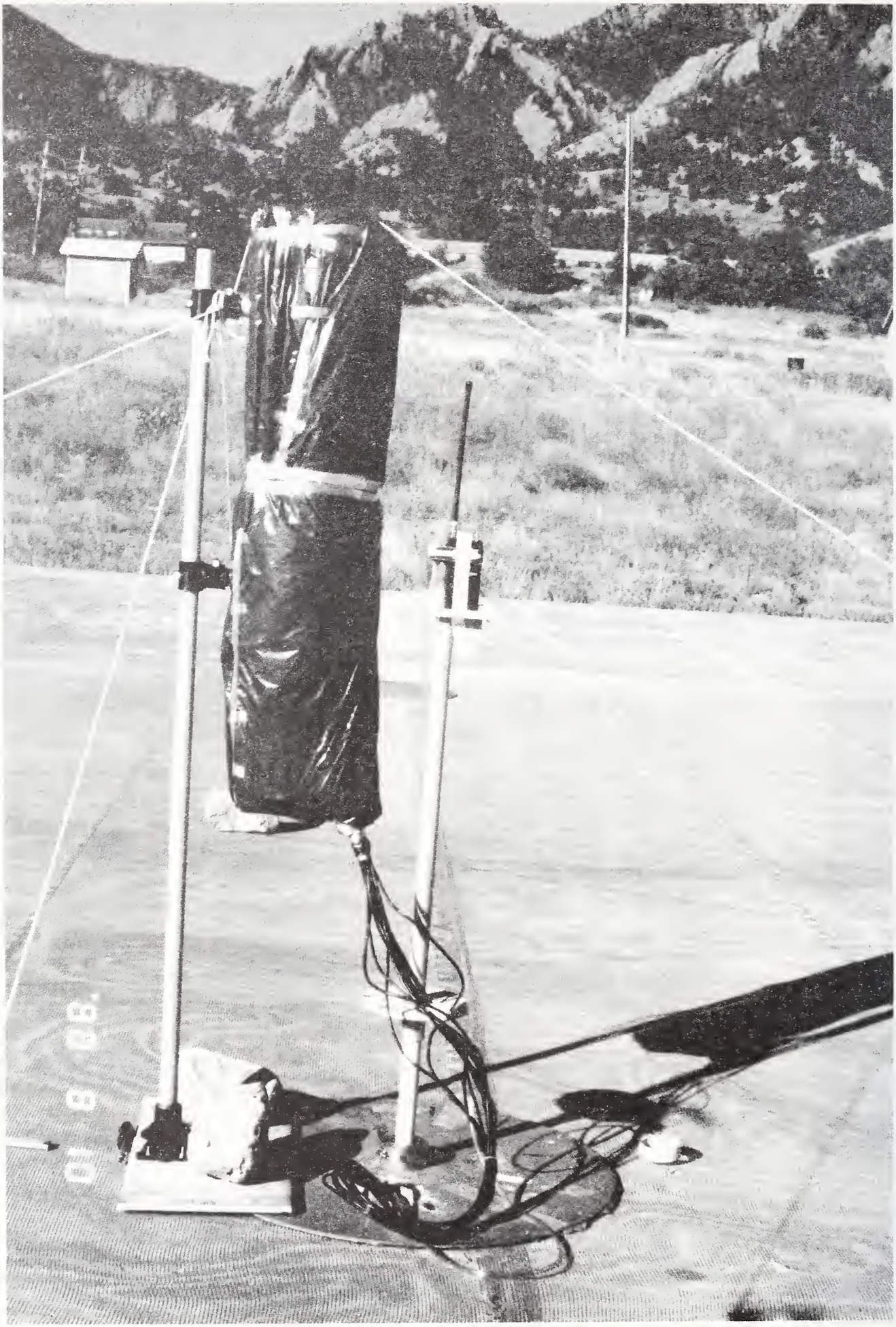

Figure 7. Picture of setup for measurements on ground screen. Note black plastic cover over probe array to block sunlight.

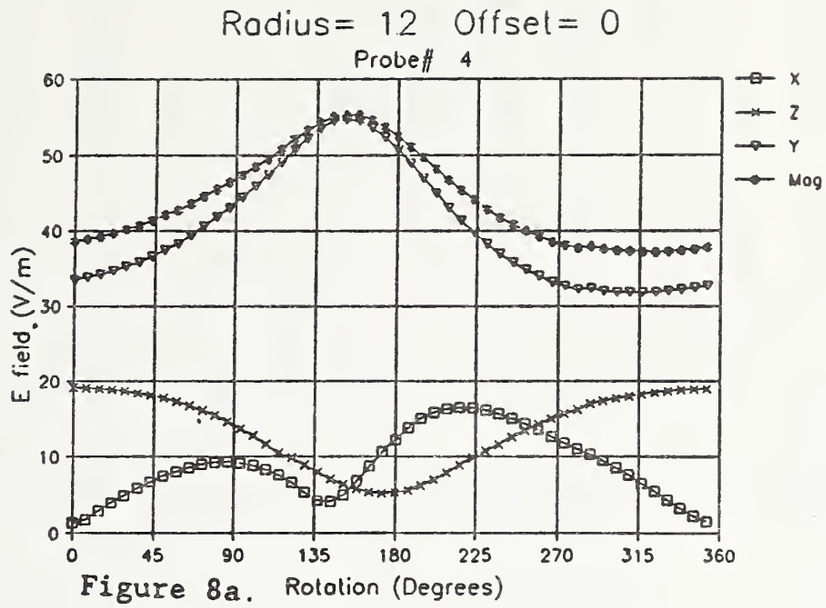

Figure 8a.

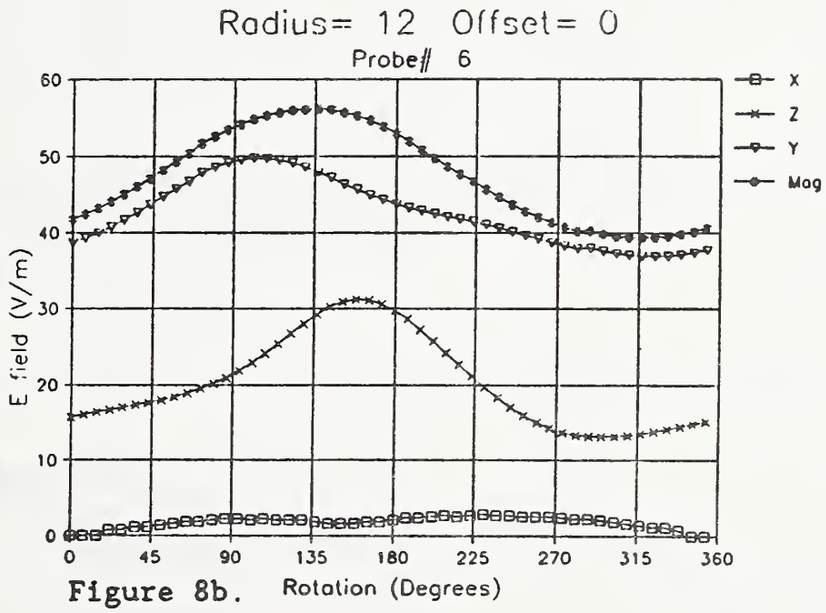

Figure 8b.

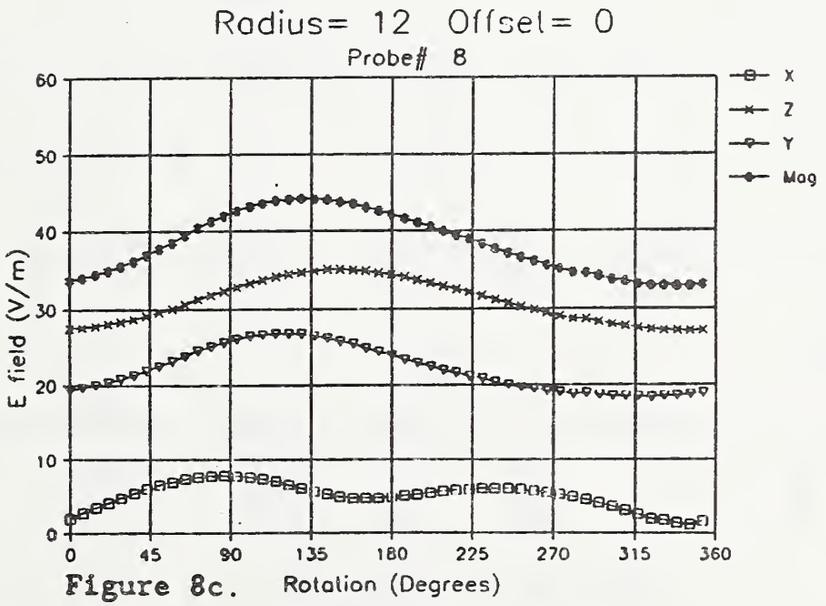

Figure 8c.

Figure 8. Display of magnitude and x, y and z components of the electric field distribution of probe #4 (figure 8a), probe #6 (figure 8b), and probe #8 (figure 8c), all at a distance of 12 centimeters from transceiver R823.

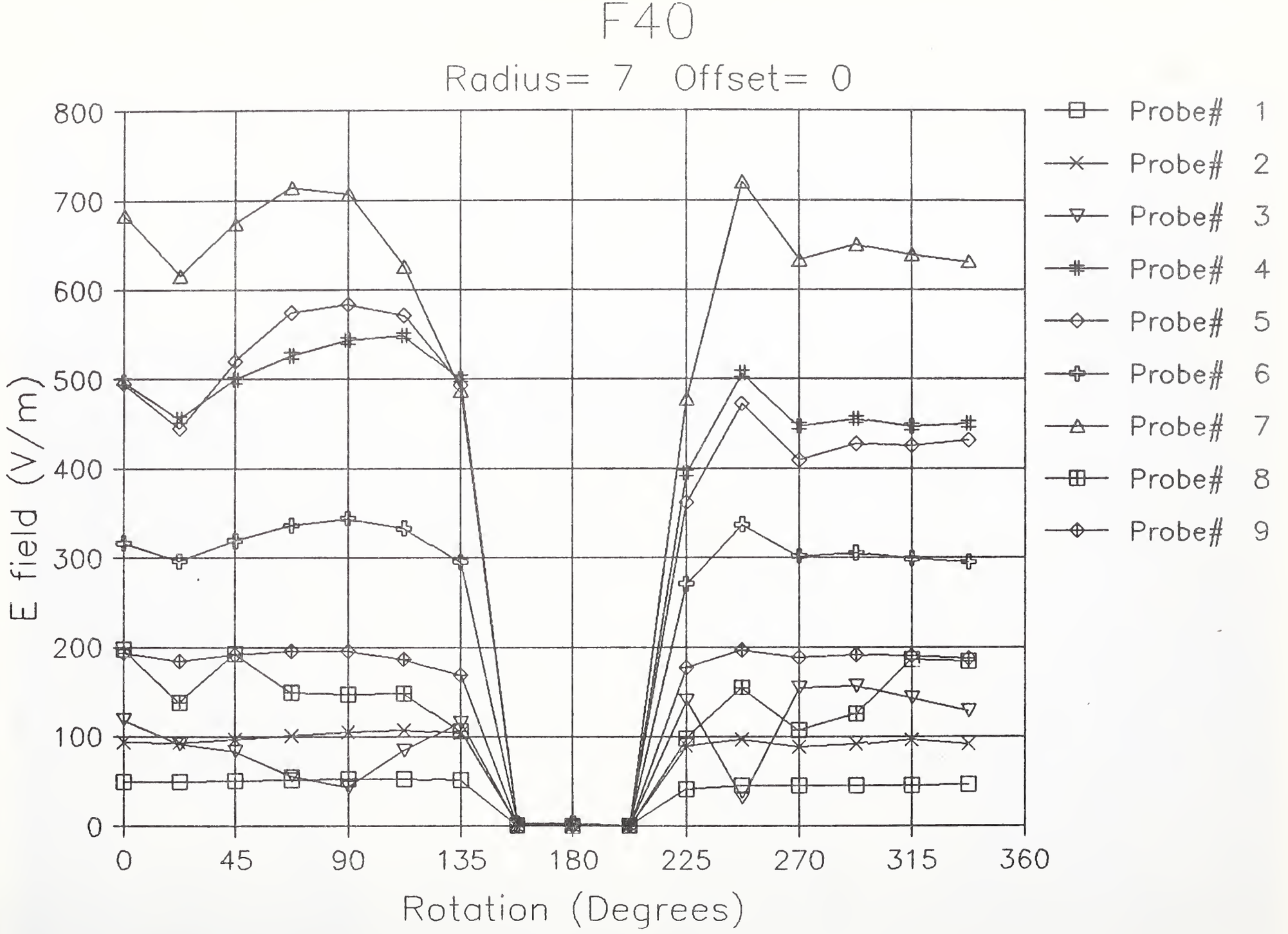

Figure 9. Plot of electric field around transceiver F40 (40 MHz) at a separation distance of 7 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

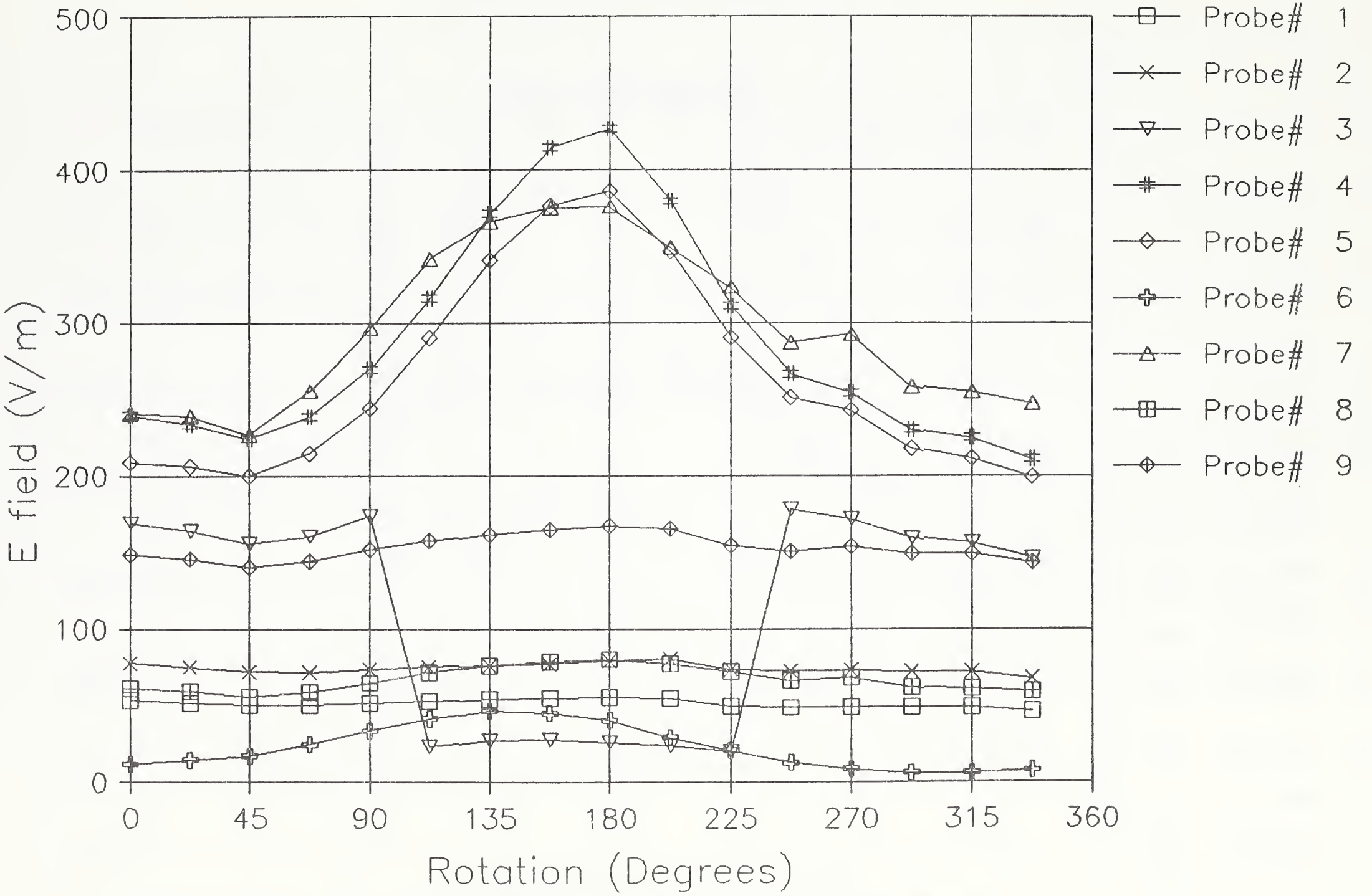

Figure 10. Plot of electric field around transceiver F40 (40 MHz) at a separation distance of 12 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

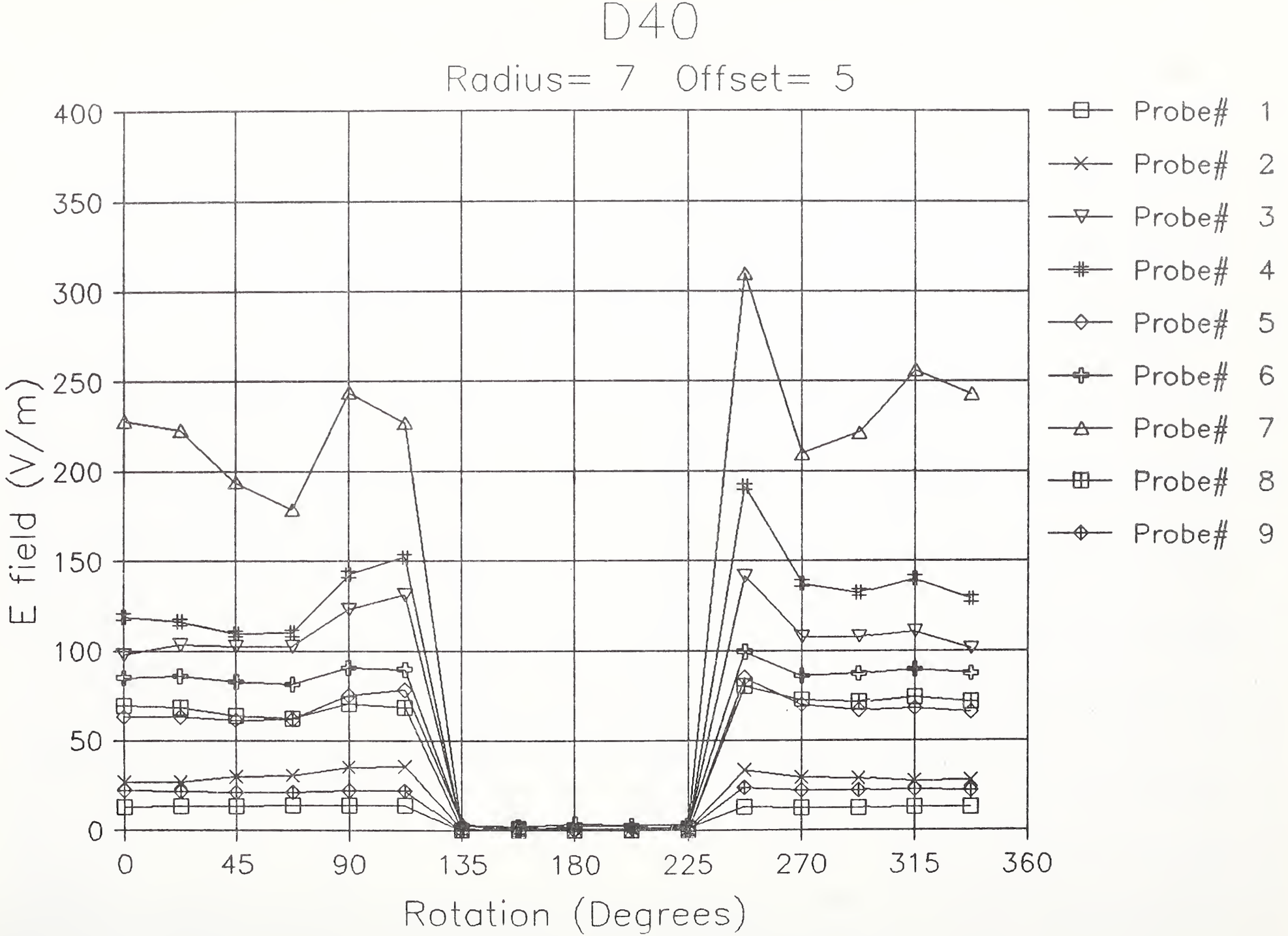

Figure 11. Plot of electric field around transceiver D40 (40 MHz) at a separation distance of 7 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

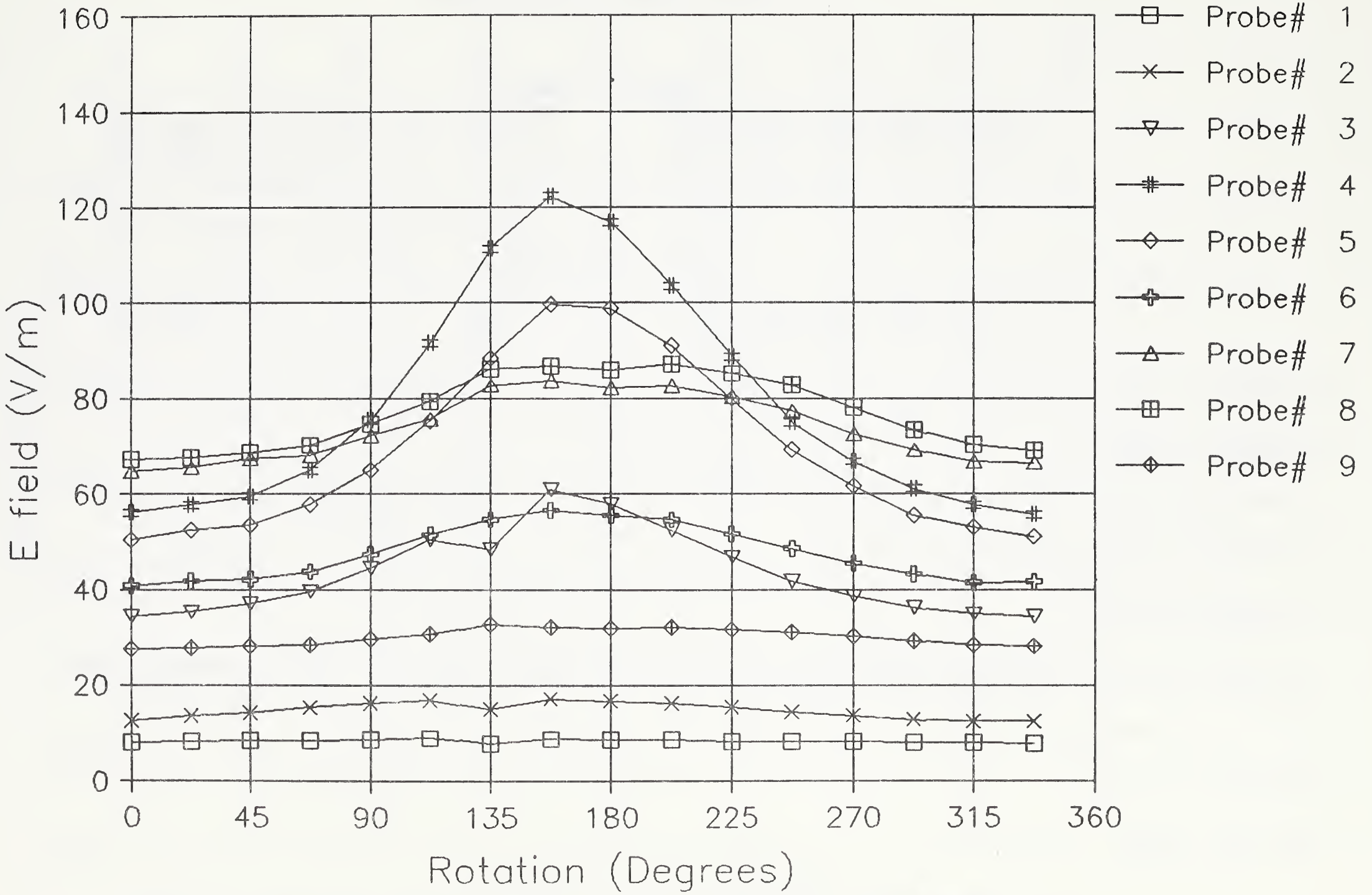

Figure 12. Plot of electric field around transceiver D40 (40 MHz) at a separation distance of 12 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

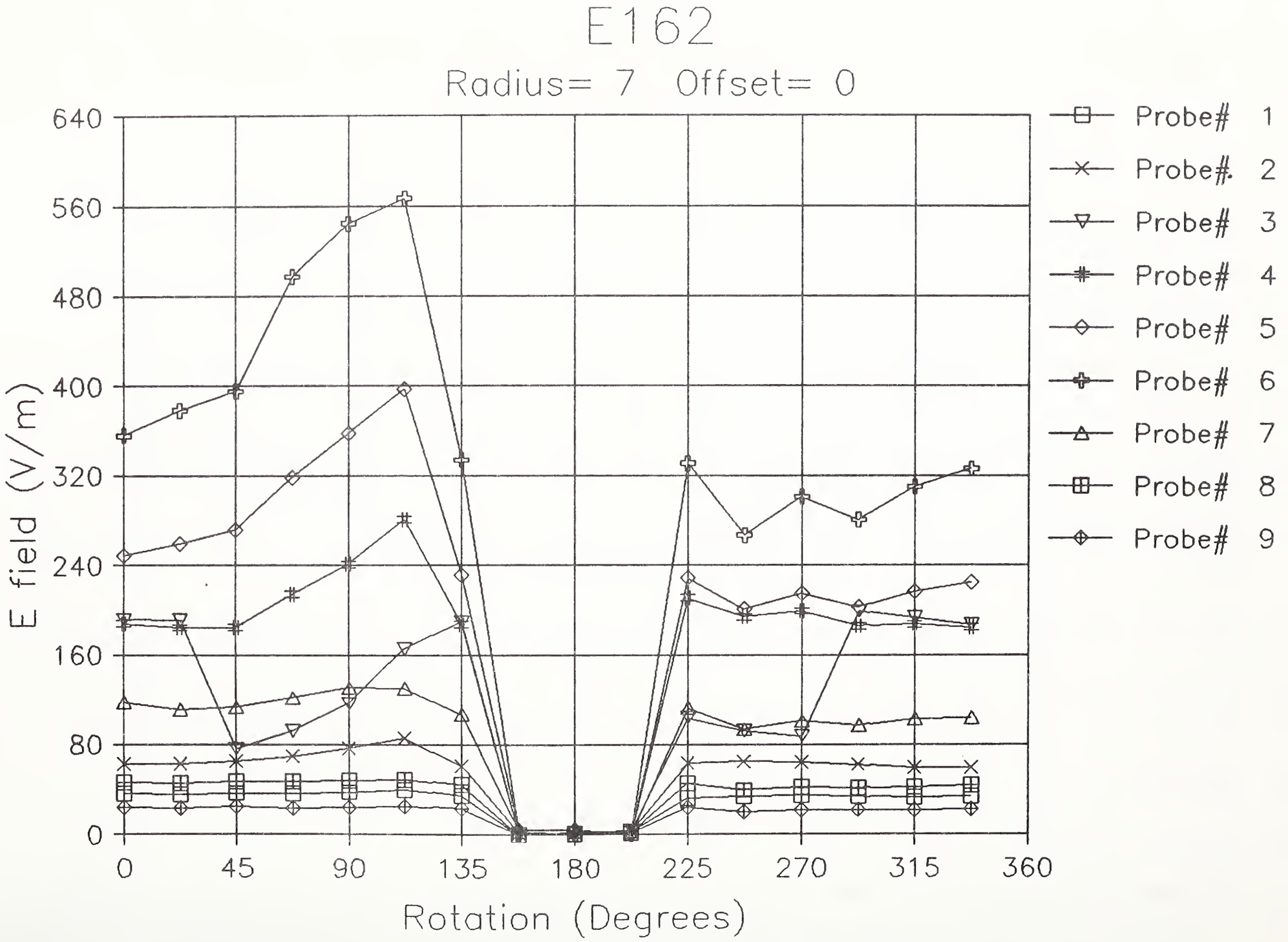

Figure 13. Plot of electric field around transceiver E162 (162 MHz) at a separation distance of 7 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

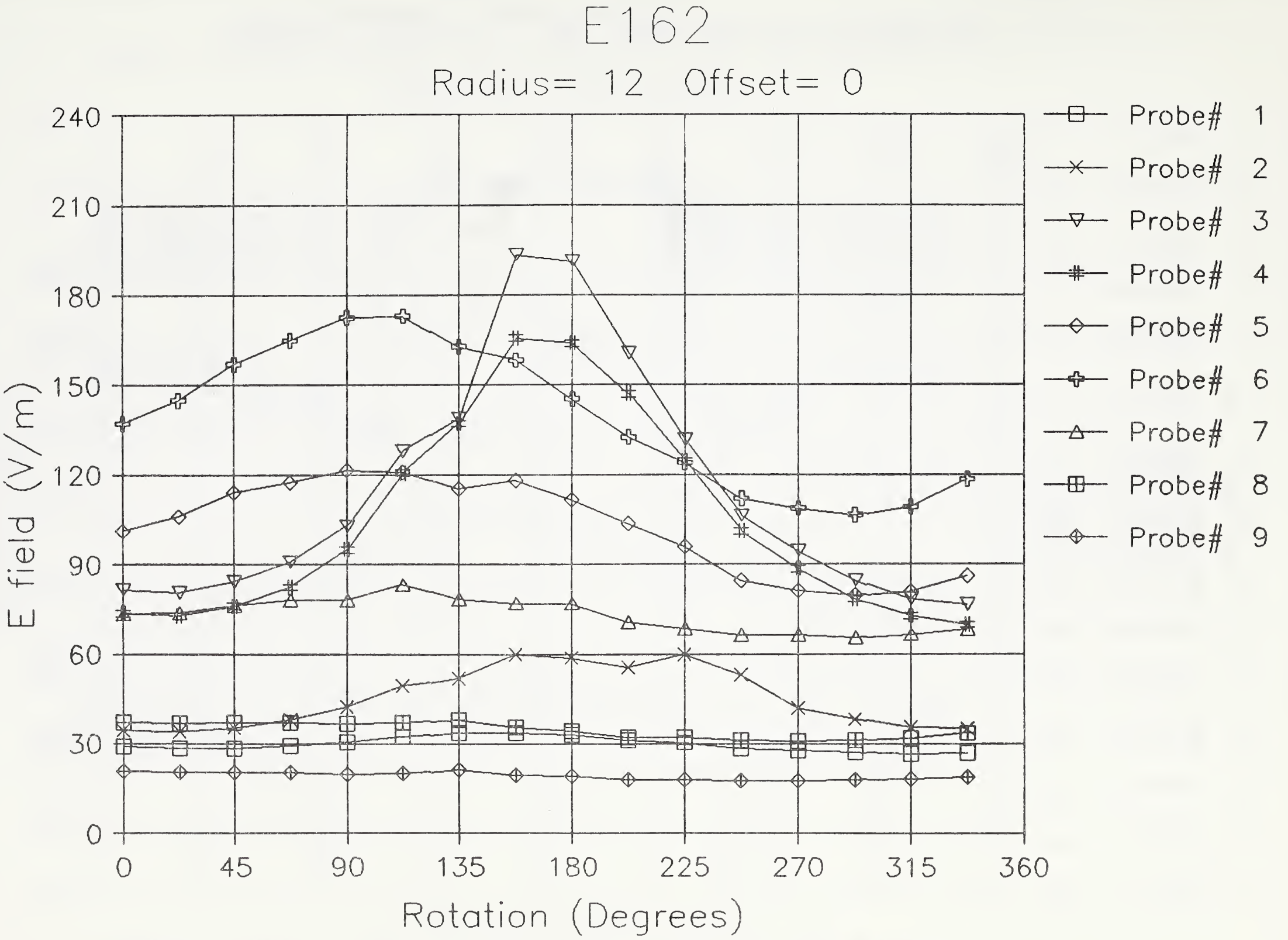

Figure 14. Plot of electric field around transceiver E162 (162 MHz) at a separation distance of 12 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

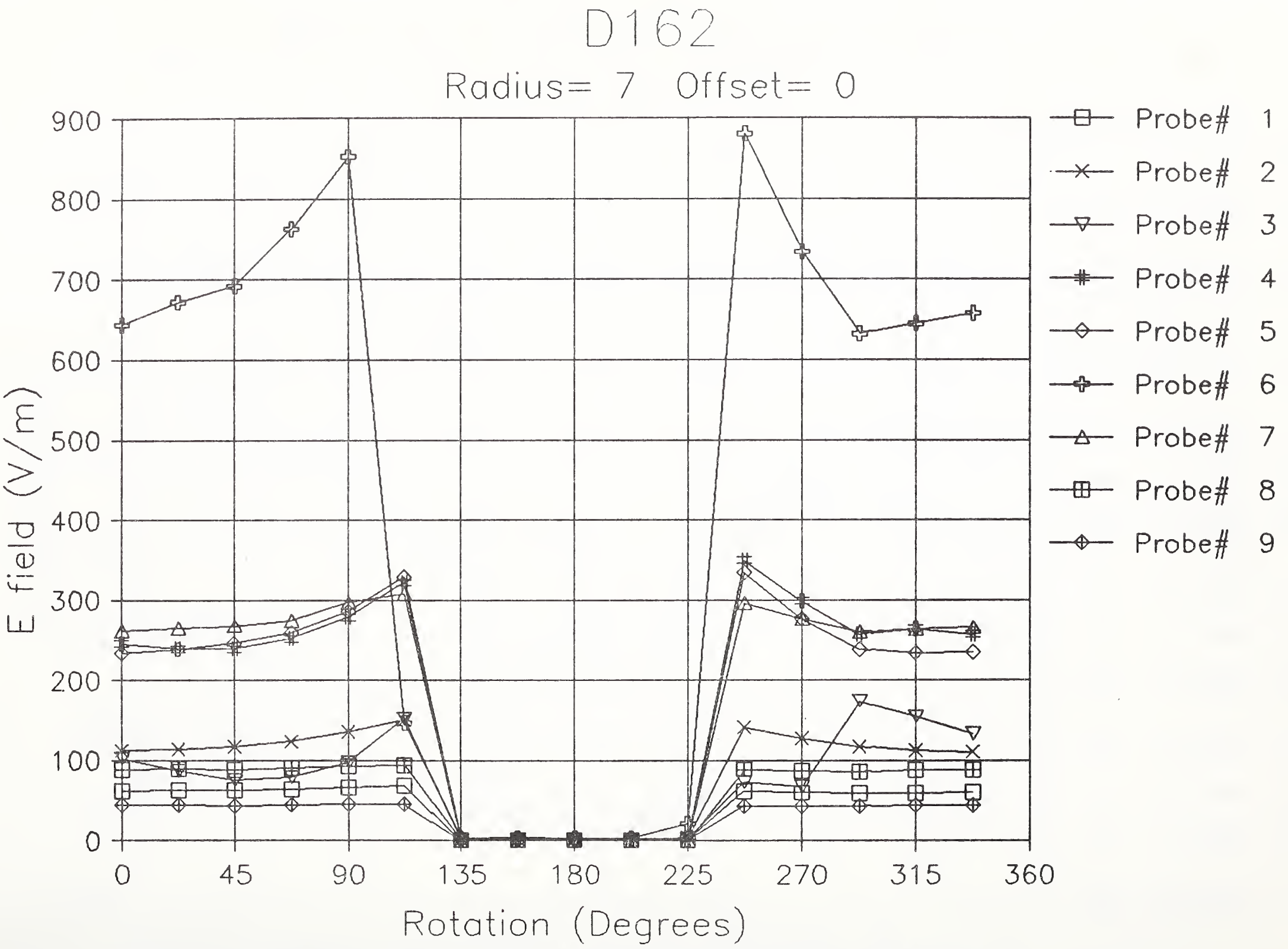

Figure 15. Plot of electric field around transceiver D162 (162 MHz) at a separation distance of 7 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

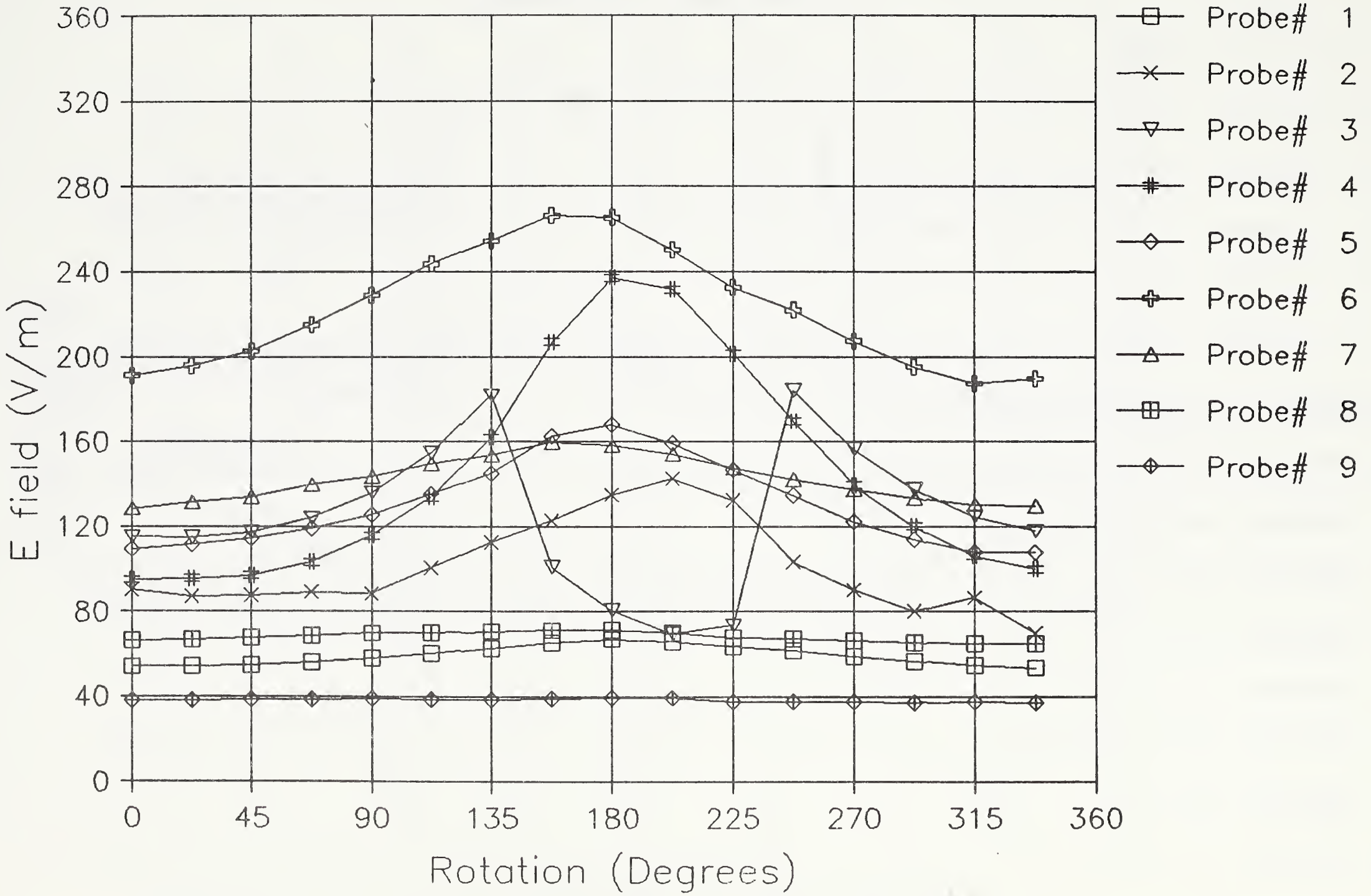

Figure 16. Plot of electric field around transceiver D162 (162 MHz) at a separation distance of 12 cm. Fields detected by probes are shown as a function of angle of rotation.

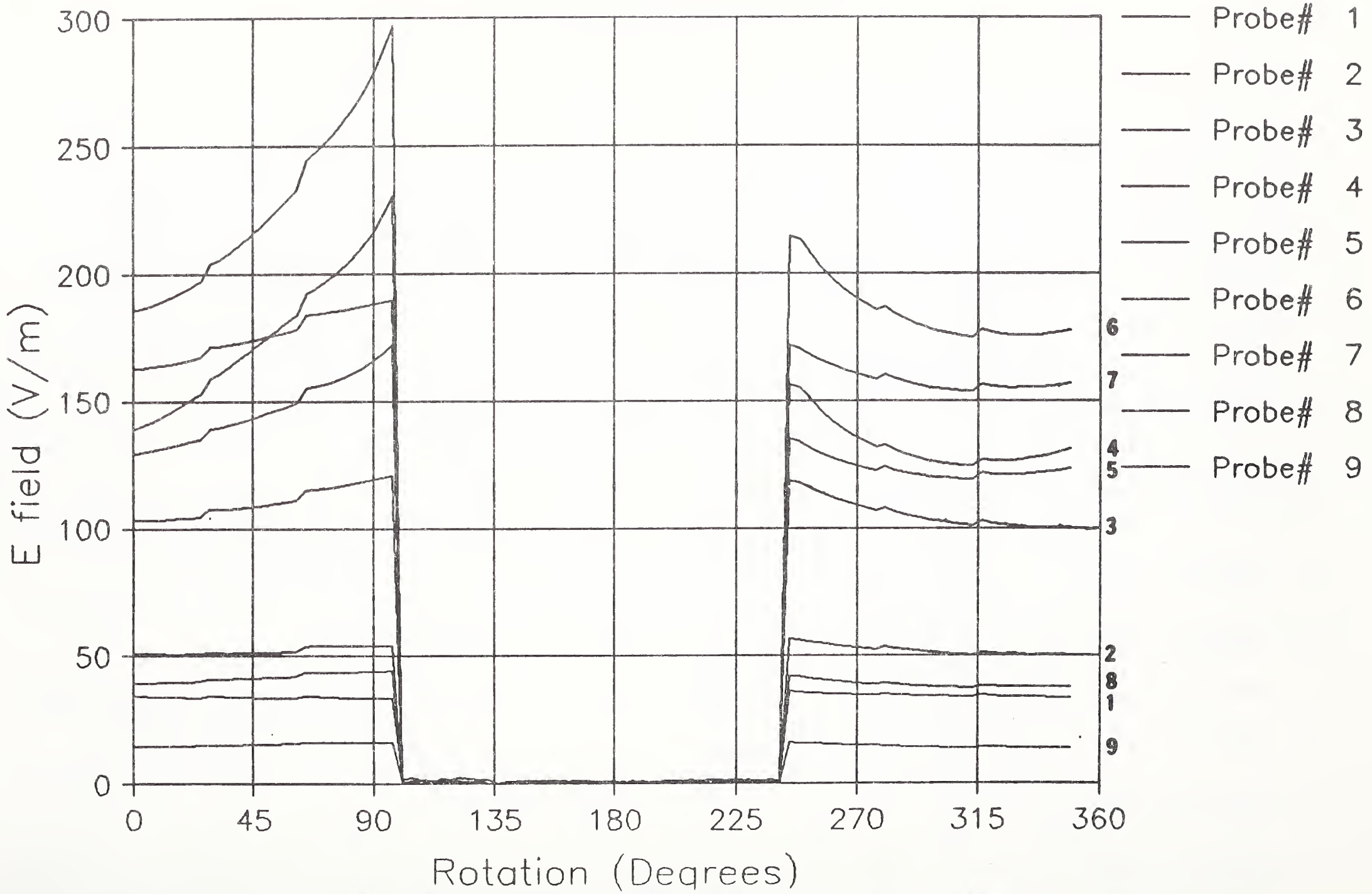

Figure 17. Plot of electric field around transceiver C464 (464 MHz) at a separation distance of 7 cm. Fields detected by 9 probes are shown as a function of angle of rotation. Effects of discharging and recharging battery may be seen.

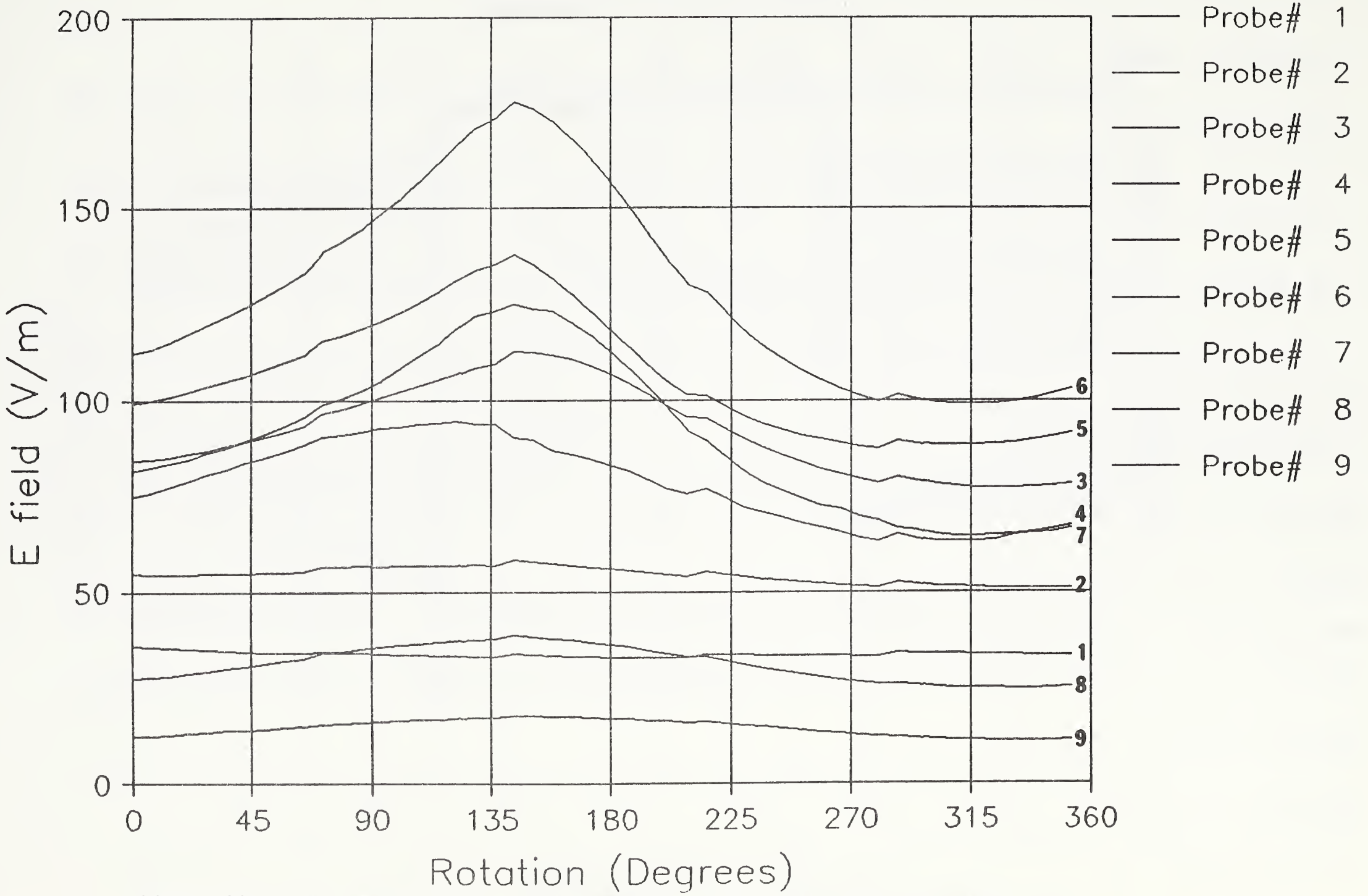

Figure 18. Plot of electric field around transceiver C464 (464 MHz) at a separation distance of 12 cm. Fields detected by 9 probes are shown as a function of angle of rotation. Effects of discharging and recharging battery may be seen.

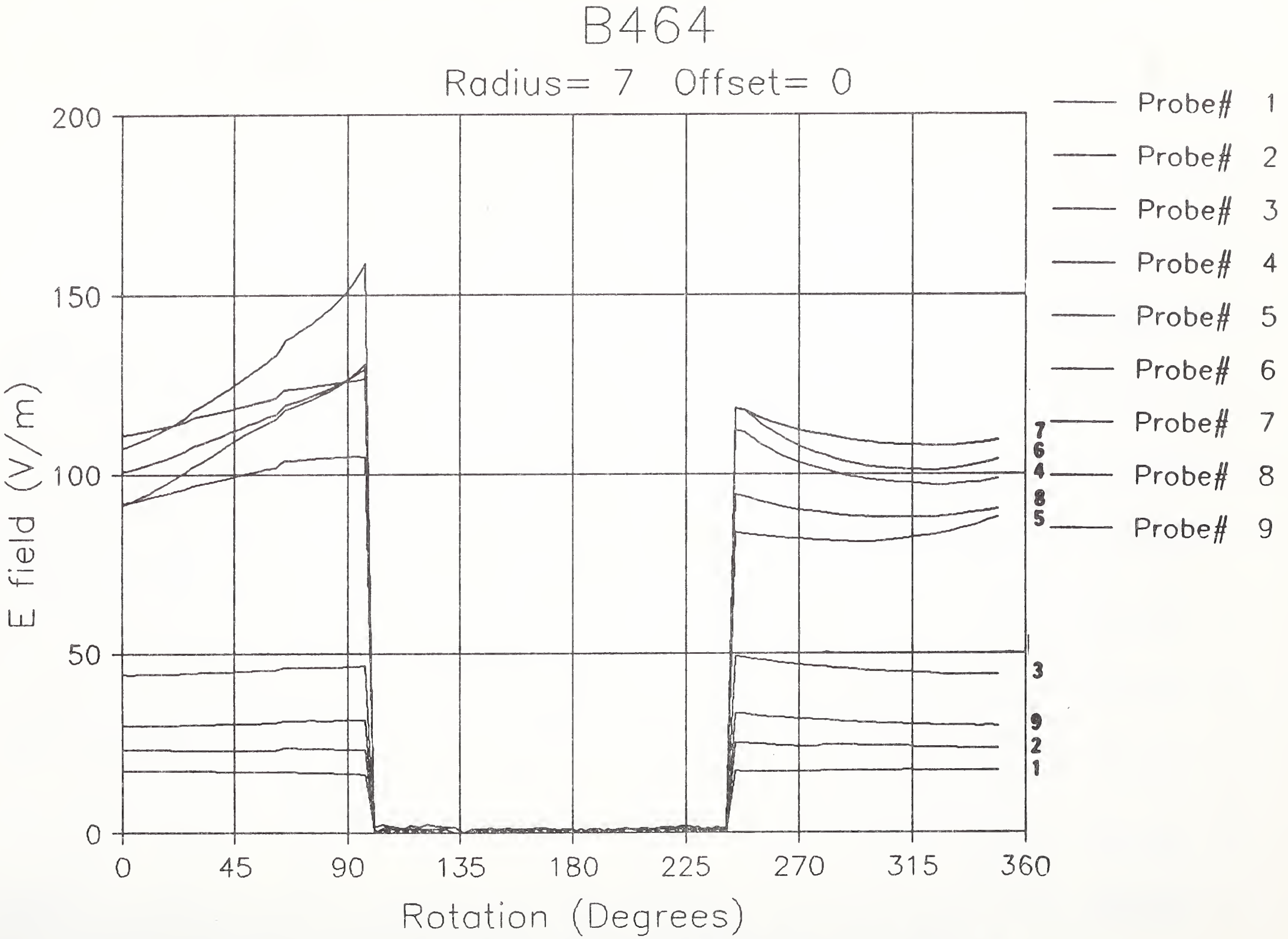

Figure 19. Plot of electric field around transceiver B464 (464 MHz) at a separation distance of 7 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

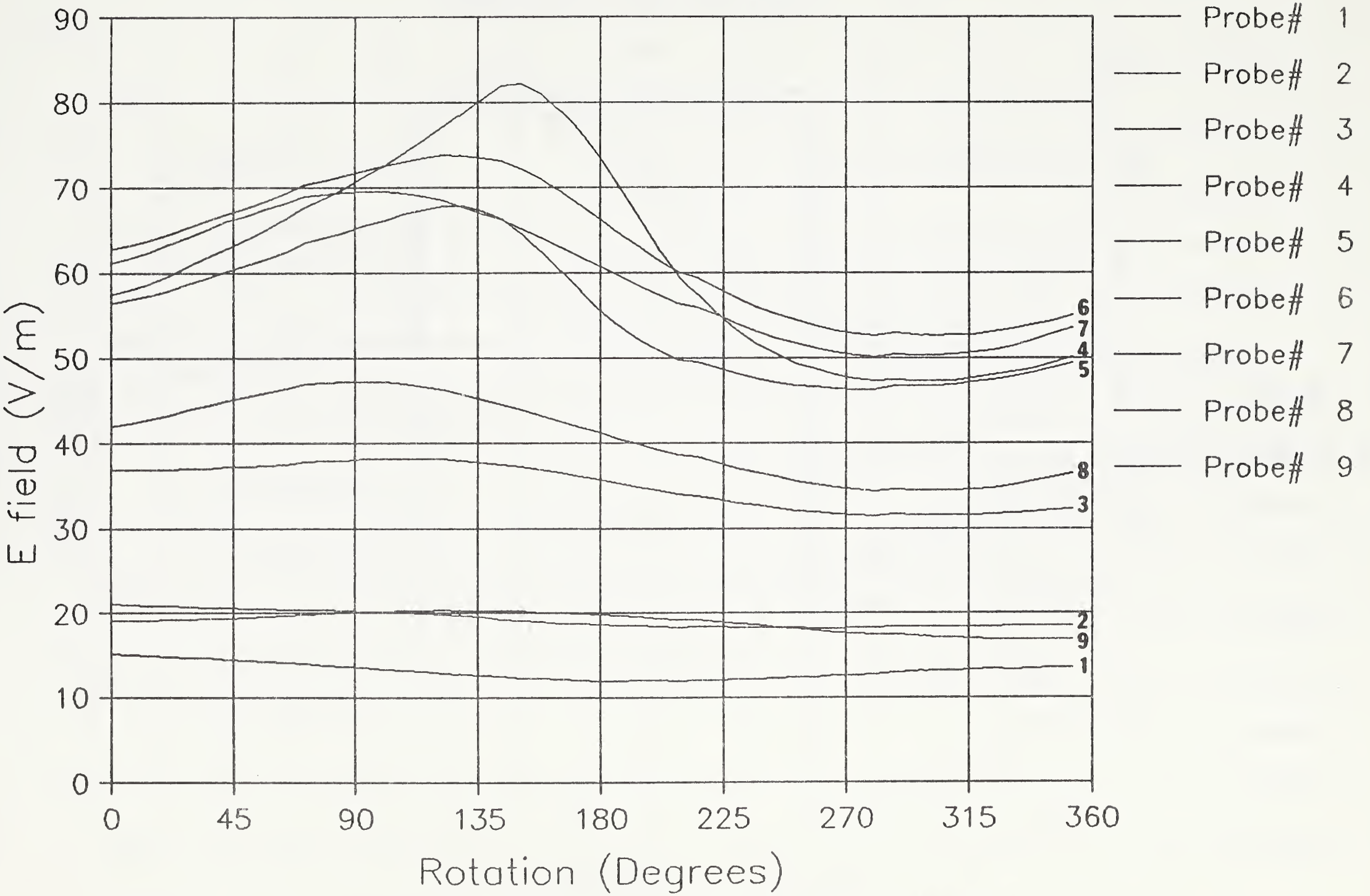

Figure 20. Plot of electric field around transceiver B464 (464 MHz) at a separation distance of 12 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

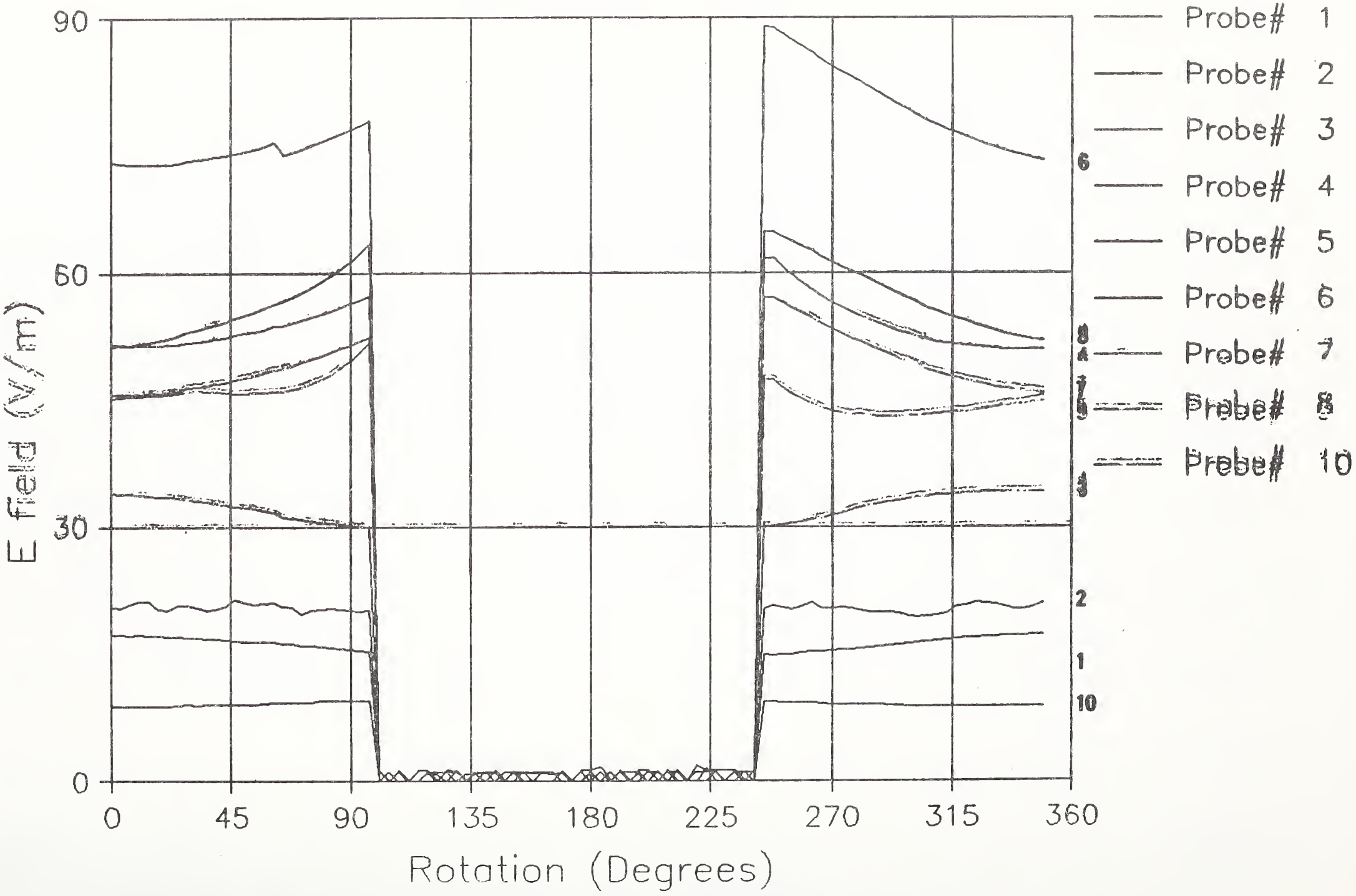

Figure 21. Plot of electric field around transceiver A823 (823 MHz) at a separation distance of 7 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

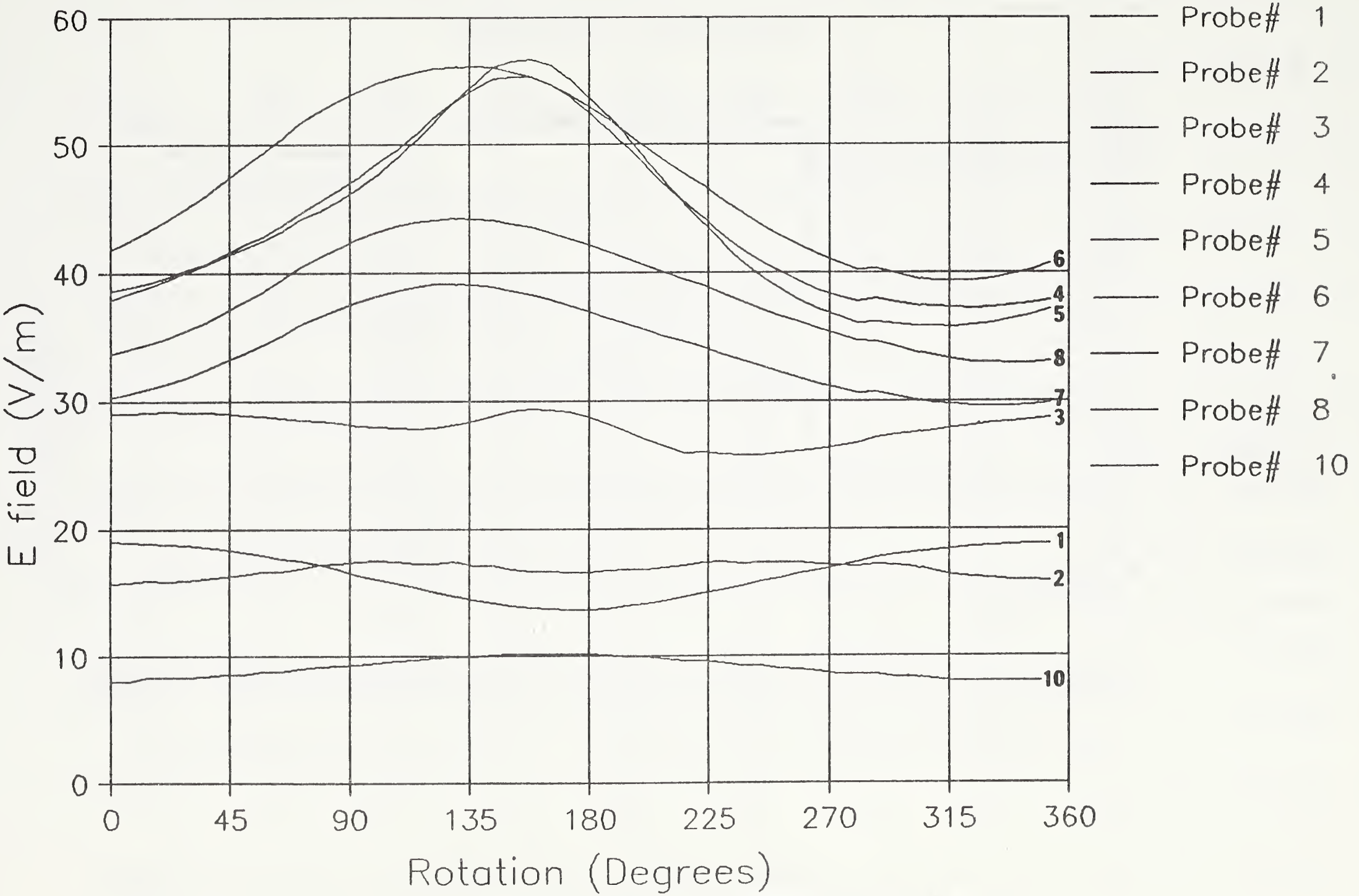

Figure 22. Plot of electric field around transceiver A823 (823 MHz) at a separation distance of 12 cm. Fields detected by 9 probes are shown as a function of angle of rotation.

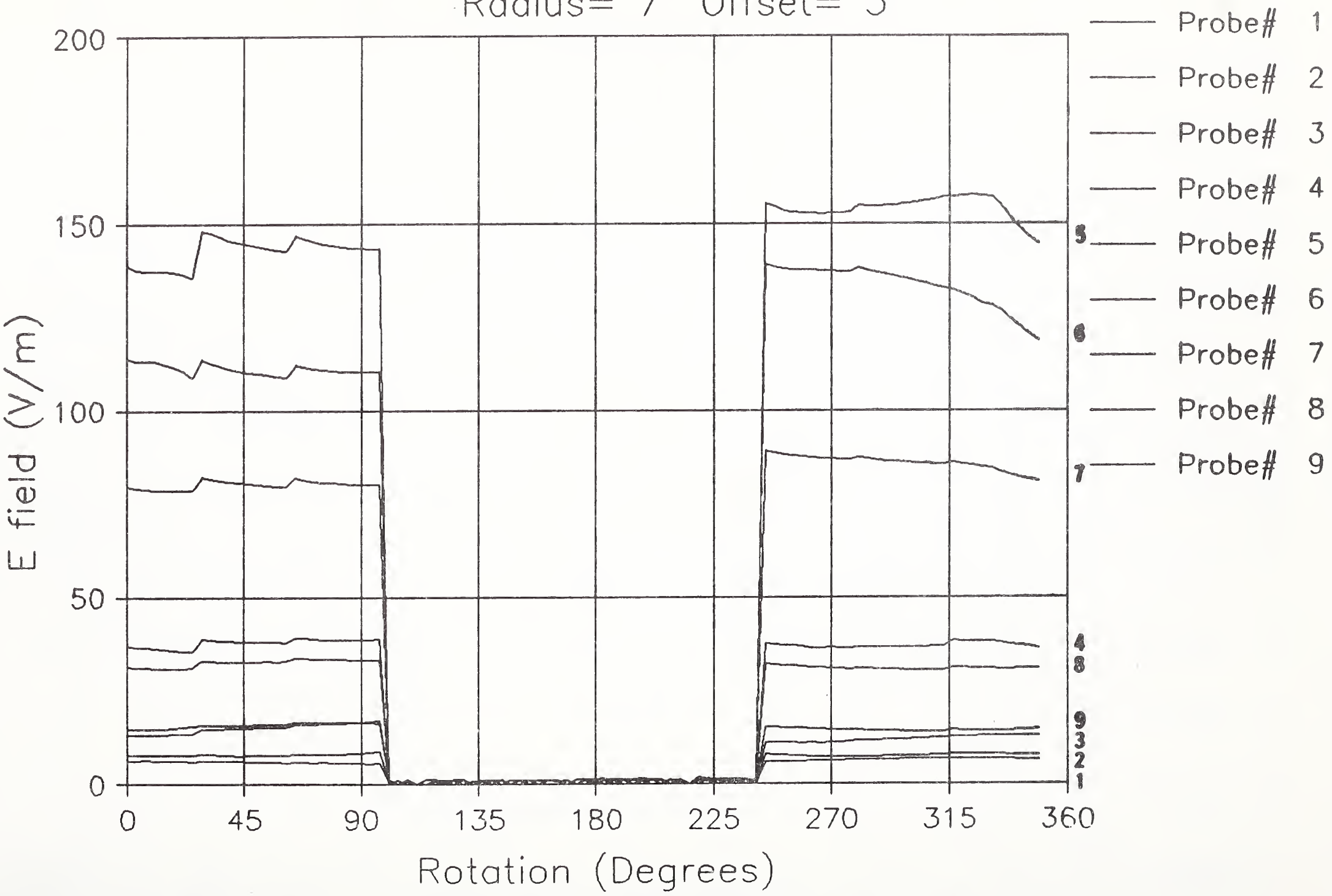

Figure 23. Plot of electric field around transceiver B823 (823 MHz) at a separation distance of 7 cm. Fields detected by 9 probes are shown as a function of angle of rotation. Effects of discharging and recharging battery may be seen.

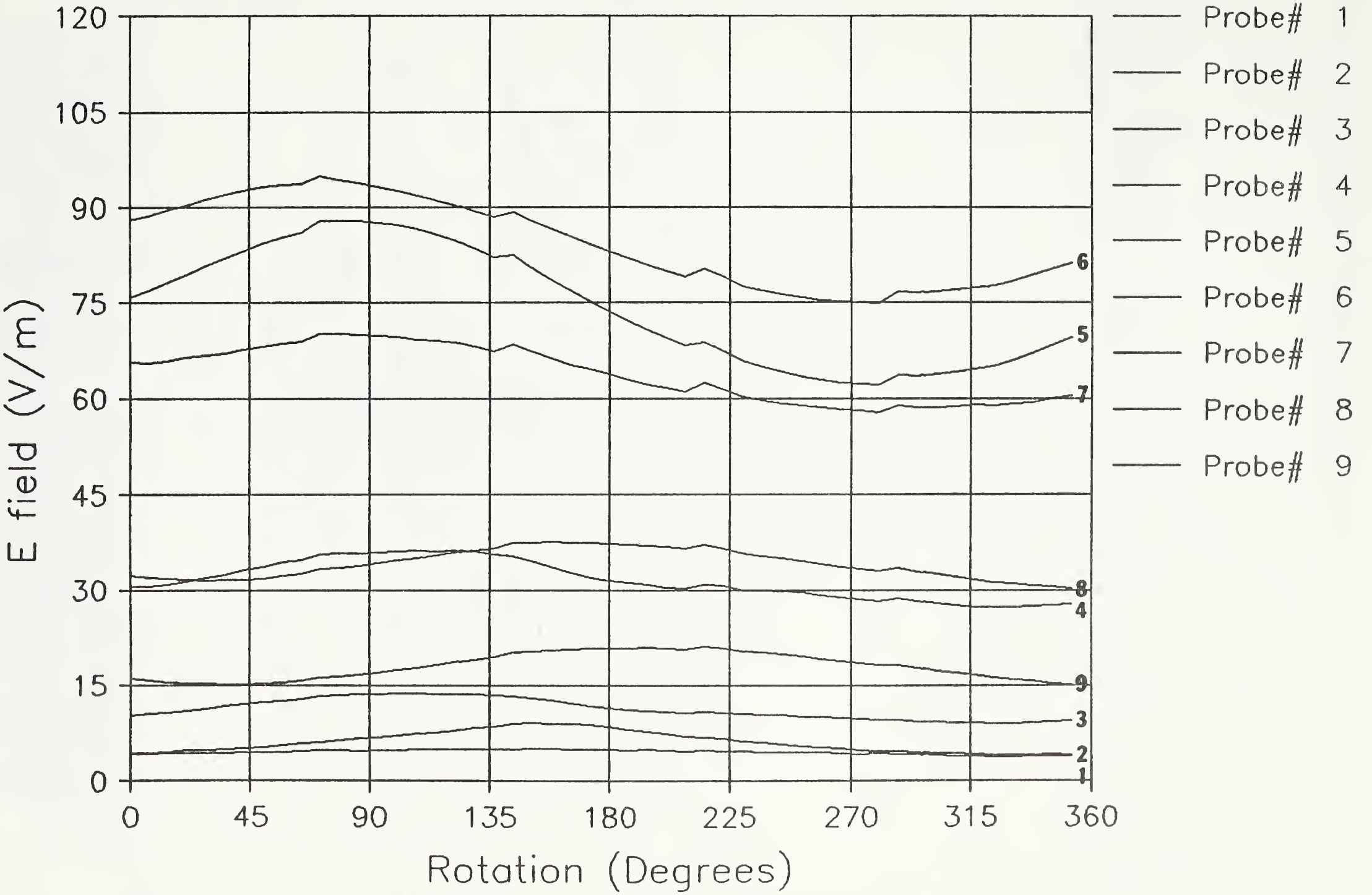

Figure 24. Plot of electric field around transceiver B823 (823 MHz) at a separation distance of 12 cm. Fields detected by 9 probes are shown as a function of angle of rotation. Effects of discharging and recharging battery may be seen.

F40
RADIUS = 7
NUMBER OF POINTS = 16
● = MAXIMUM POINT: 720.30 -112.50

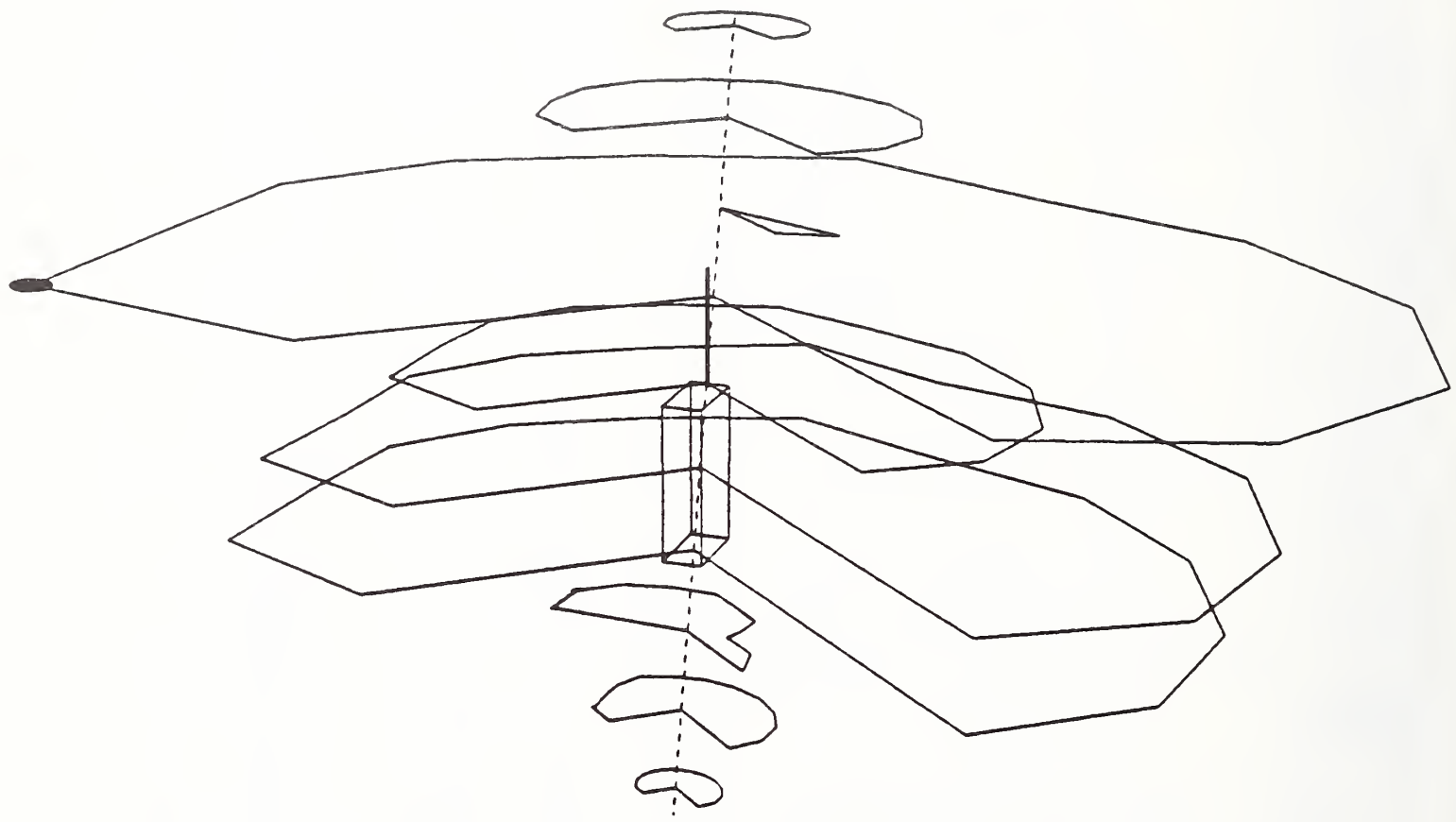

Figure 25. Three-dimensional plot of magnitude of electric field around transceiver F40 (40 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 7). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

F40
RADIUS - 12
NUMBER OF POINTS - 16
● - MAXIMUM POINT: 426.43 180.00

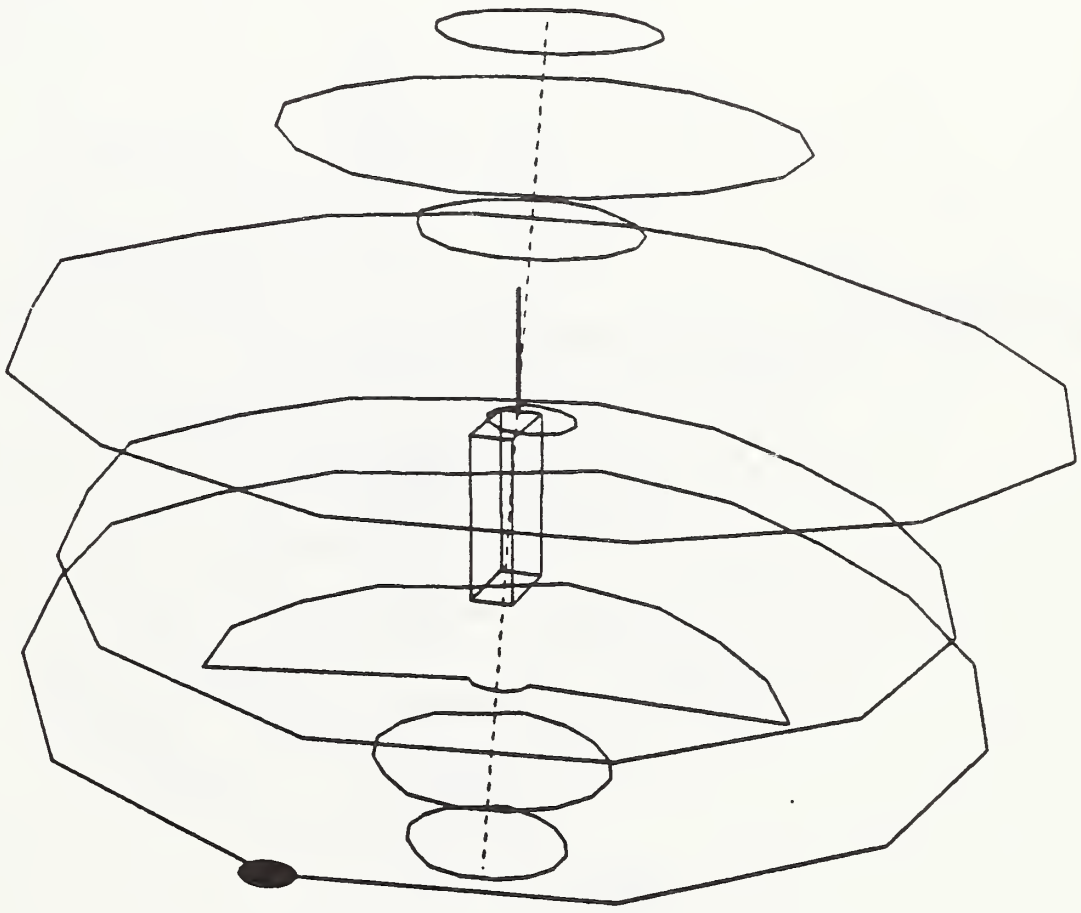

Figure 26. Three-dimensional plot of magnitude of electric field around transceiver F40 (40 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 12). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

D40
RADIUS = 7
NUMBER OF POINTS = 16
● = MAXIMUM POINT: 309.60 -112.50

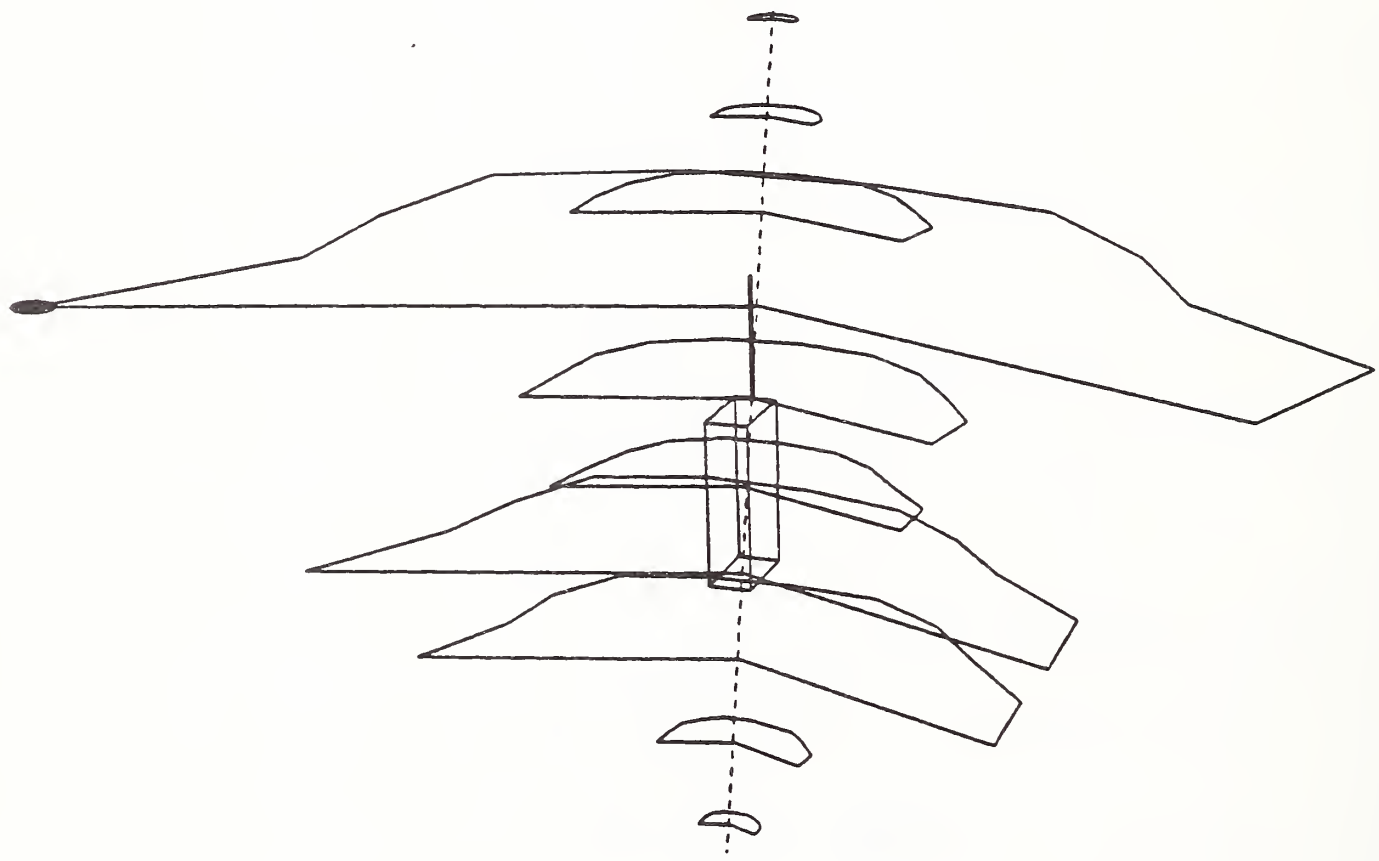

Figure 27. Three-dimensional plot of magnitude of electric field around transceiver D40 (40 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 7). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

D40
RADIUS = 12
NUMBER OF POINTS = 16
● - MAXIMUM POINT: 122.30 157.50

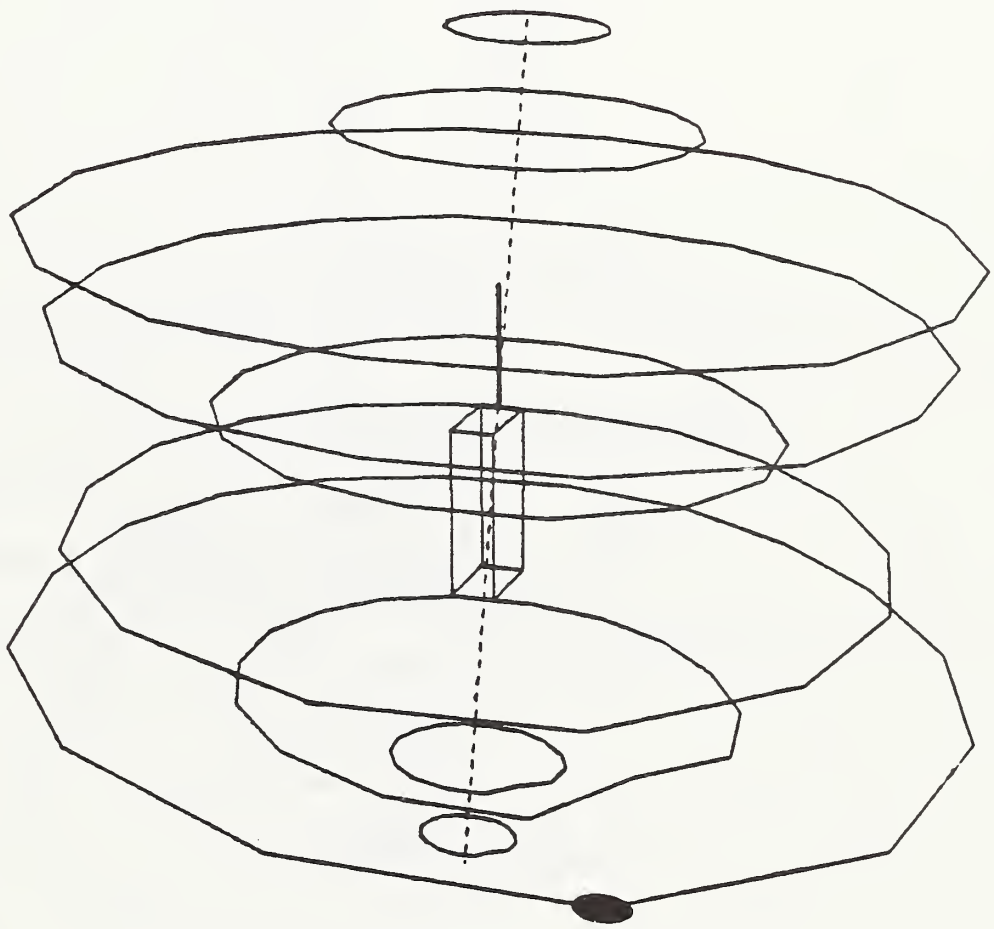

Figure 28. Three-dimensional plot of magnitude of electric field around transceiver D40 (40 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 12). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

E162
RADIUS = 7
NUMBER OF POINTS = 16
● = MAXIMUM POINT: 566.61 112.50

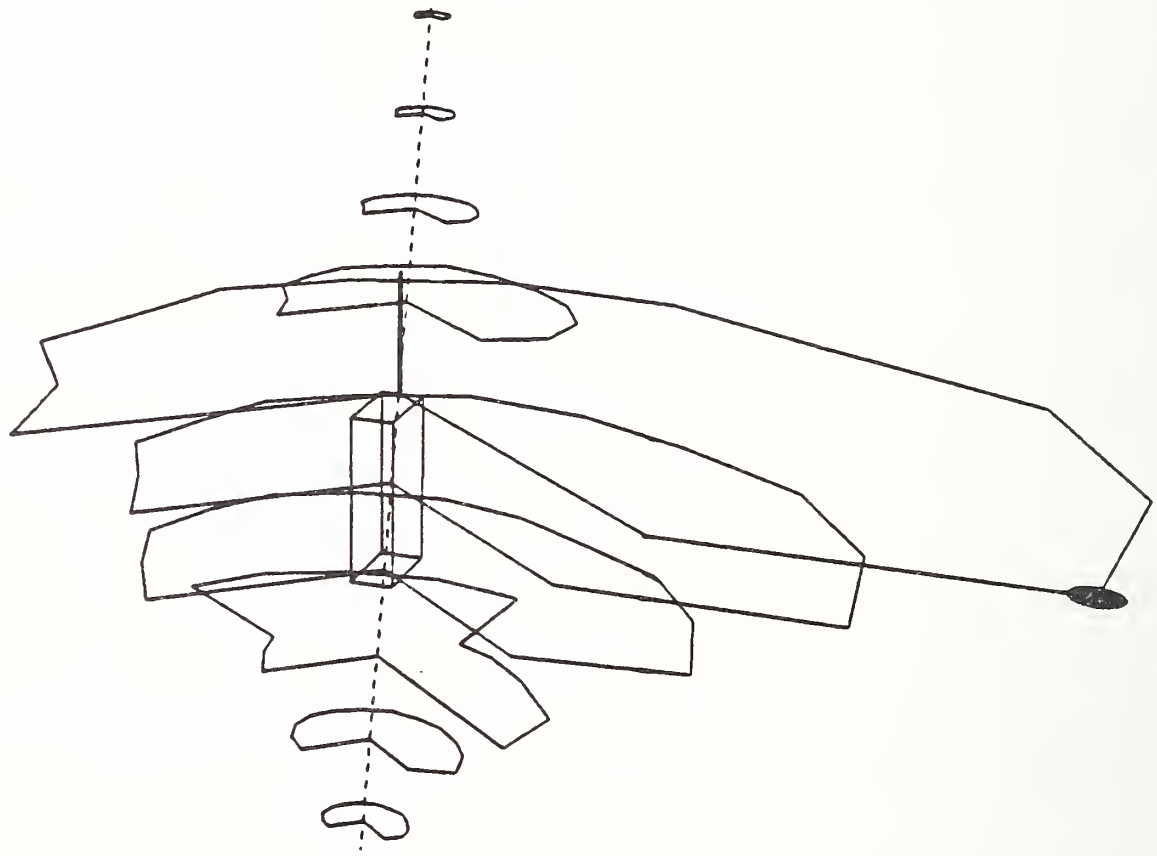

Figure 29. Three-dimensional plot of magnitude of electric field around transceiver E162 (162 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 7). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

E162
RADIUS - 12
NUMBER OF POINTS - 16
- MAXIMUM POINT: 193.38 157.50

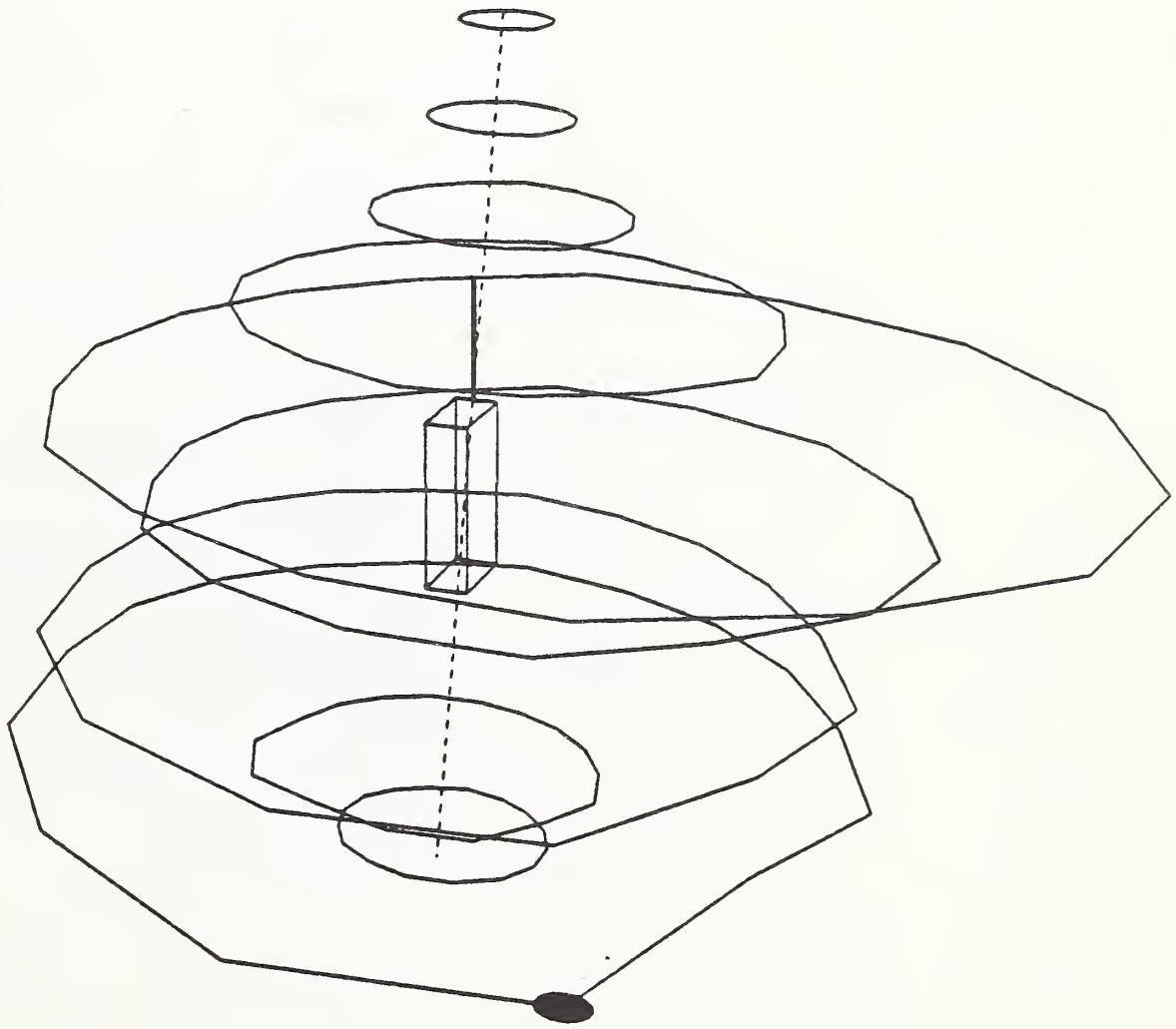

Figure 30. Three-dimensional plot of magnitude of electric field around transceiver E162 (162 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 12). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

D162
RADIUS = 7
NUMBER OF POINTS = 16
● = MAXIMUM POINT: 880.30 -112.50

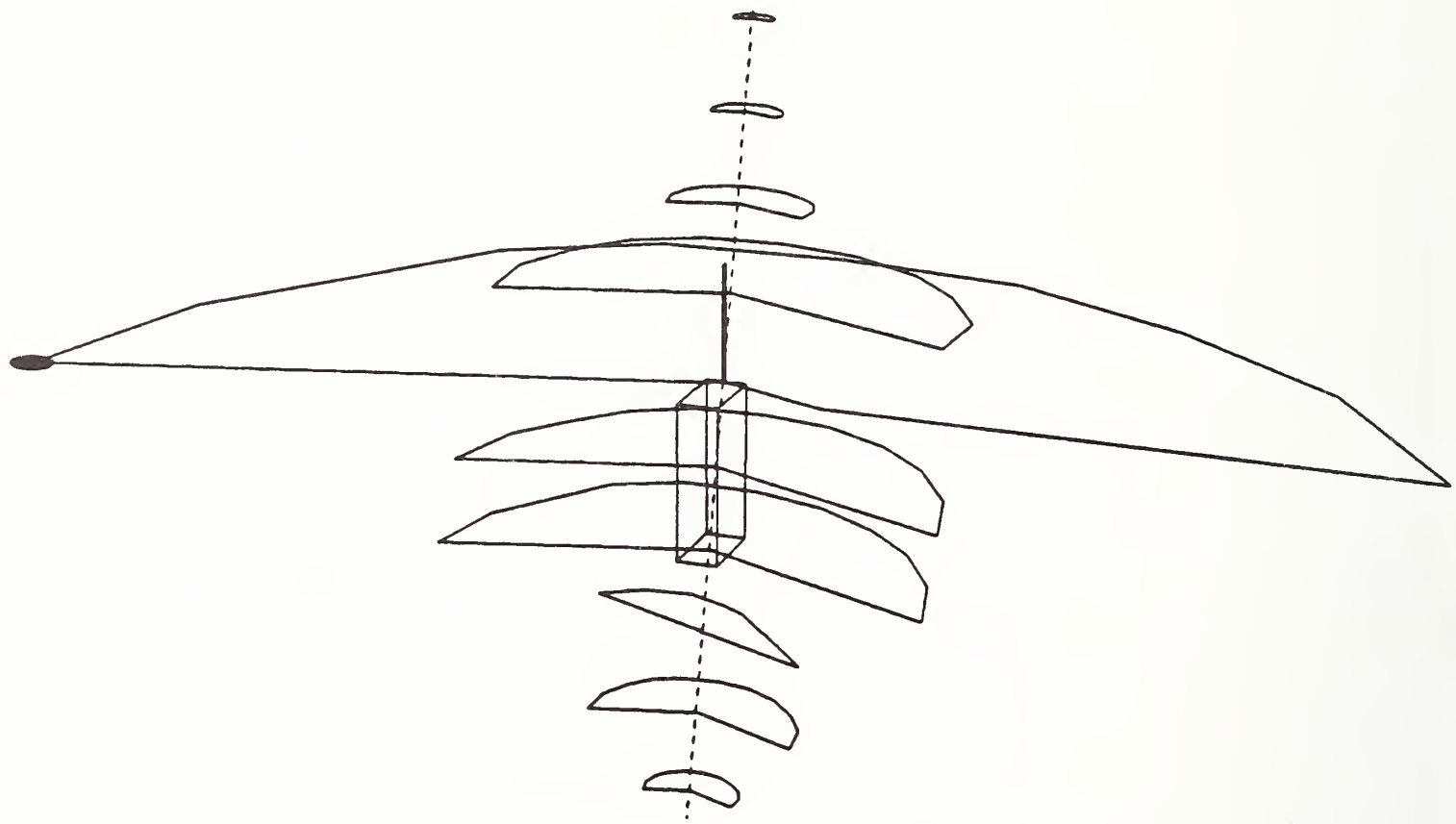

Figure 31. Three-dimensional plot of magnitude of electric field around transceiver D162 (162 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 7). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

D162
RADIUS = 12
NUMBER OF POINTS = 16
● = MAXIMUM POINT: 266.10 157.50

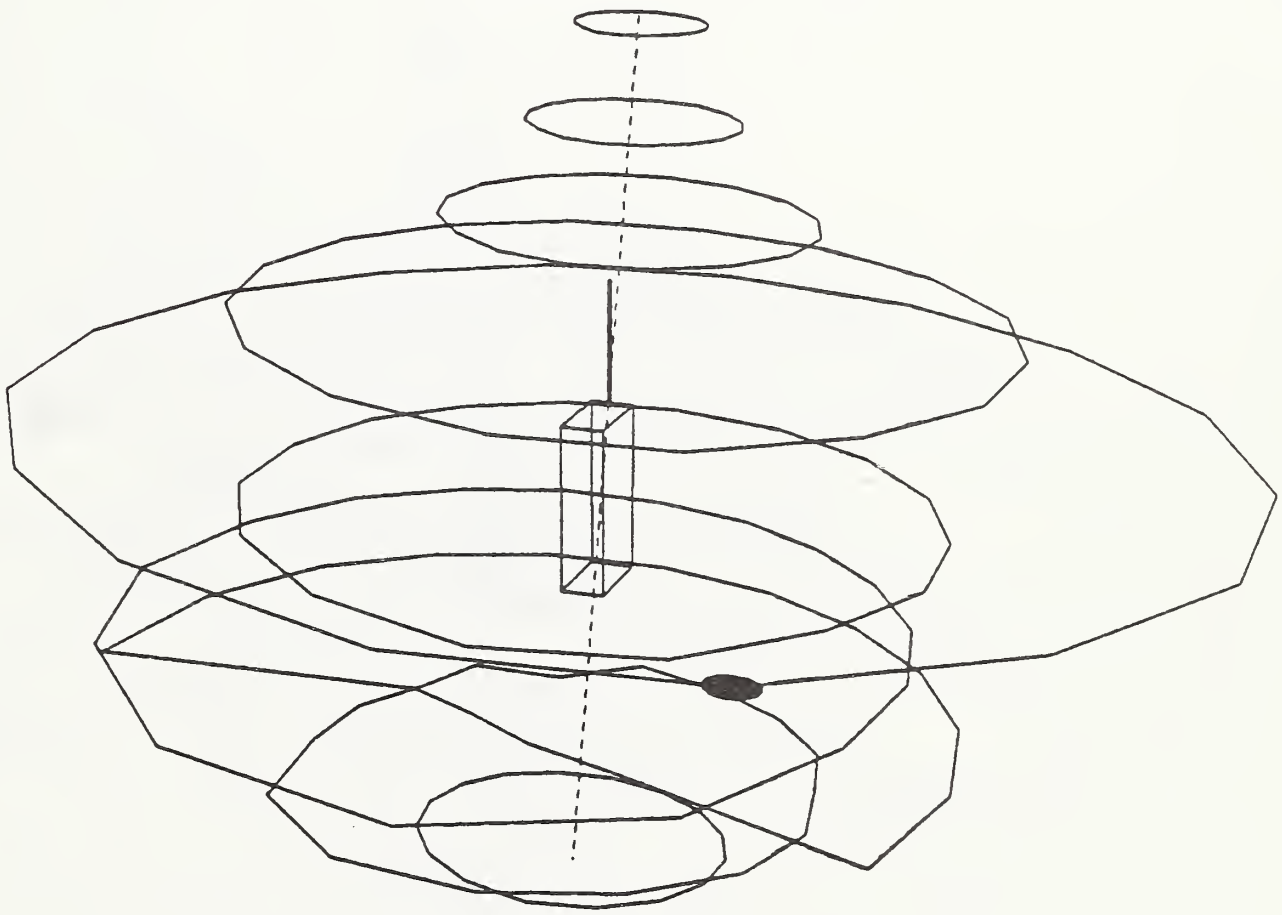

Figure 32. Three-dimensional plot of magnitude of electric field around transceiver D162 (162 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 12). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

C464
RADIUS - 7
NUMBER OF POINTS - 100
● = MAXIMUM POINT: 297.11 104.40

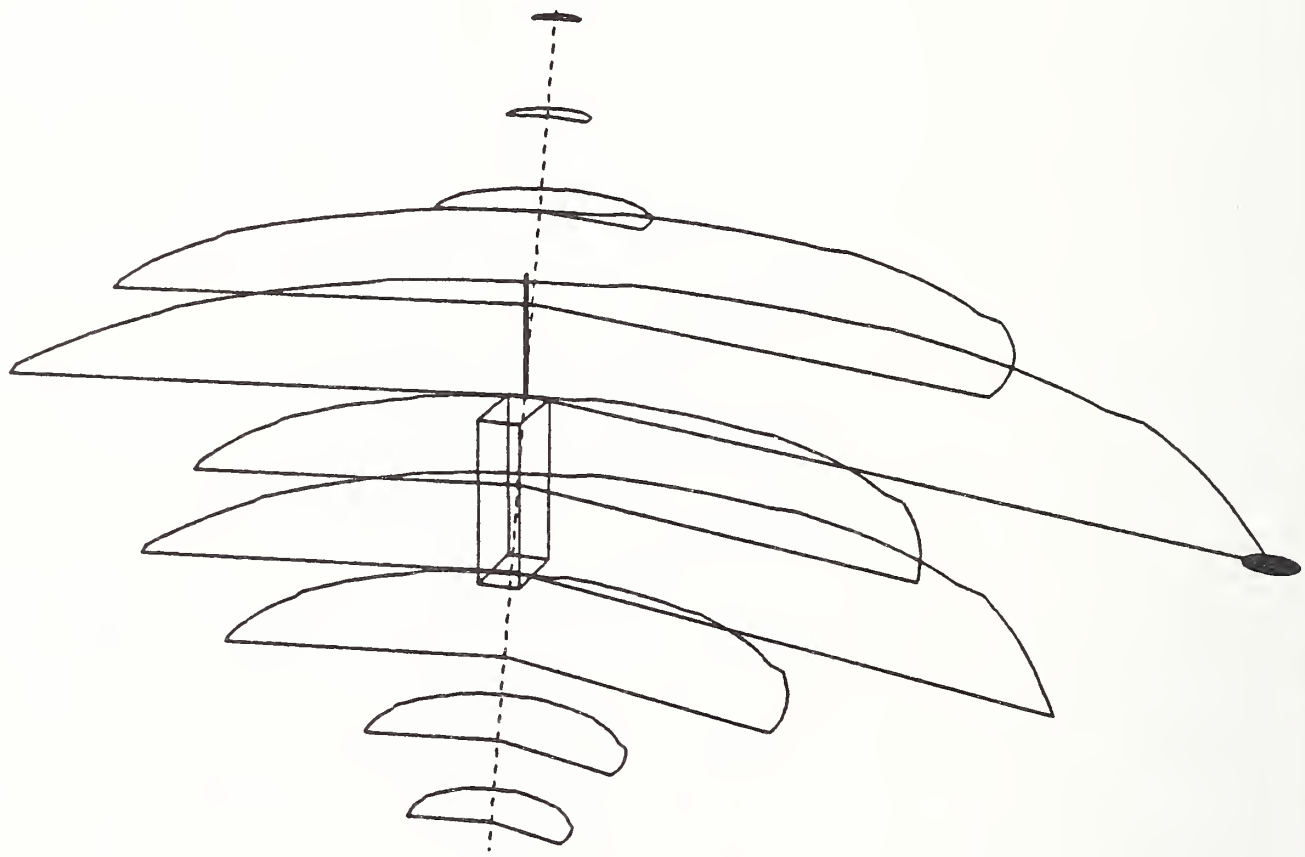

Figure 33. Three-dimensional plot of magnitude of electric field around transceiver C464 (464 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 7). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

C464
RADIUS - 12
NUMBER OF POINTS - 50
- MAXIMUM POINT: 179.84 144.00

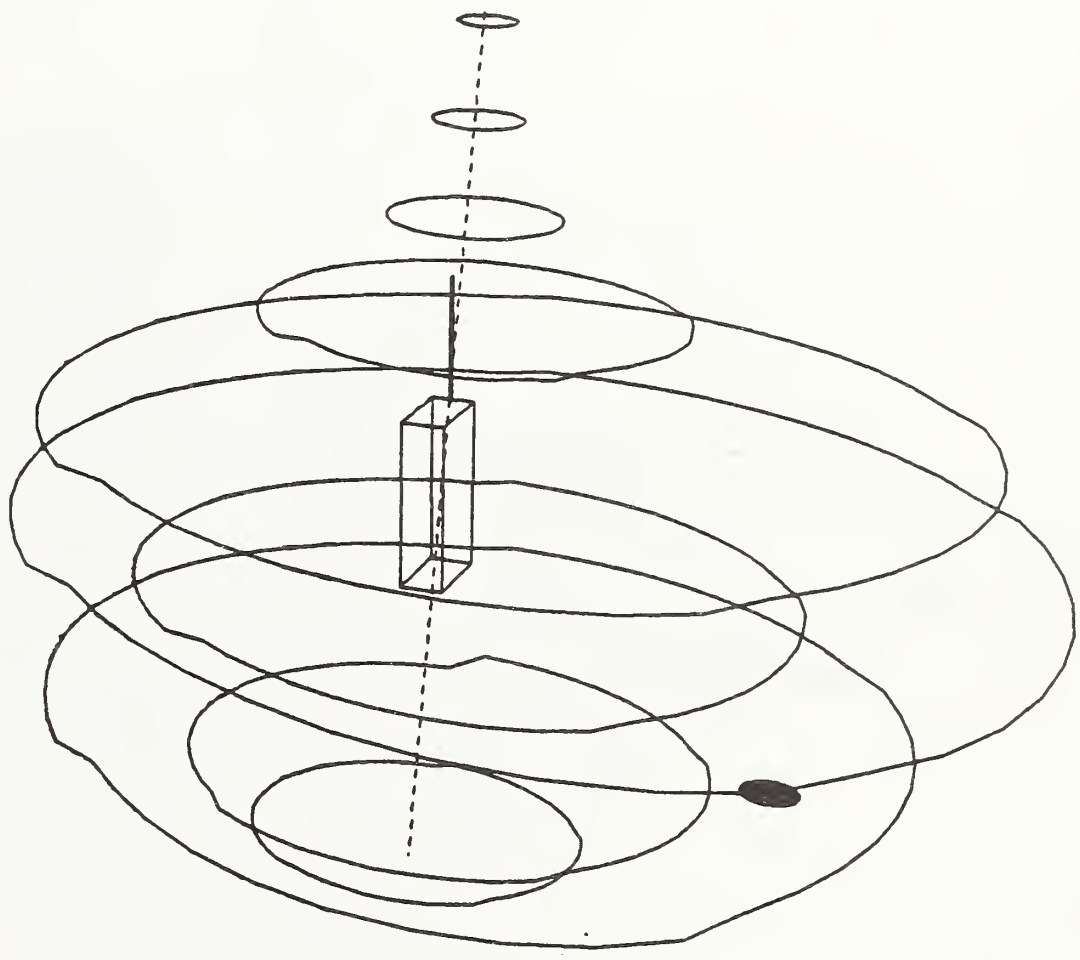

Figure 34. Three-dimensional plot of magnitude of electric field around transceiver C464 (464 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 12). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

C464G
RADIUS = 12
NUMBER OF POINTS = 16
● = MAXIMUM POINT: 148.53 -157.50

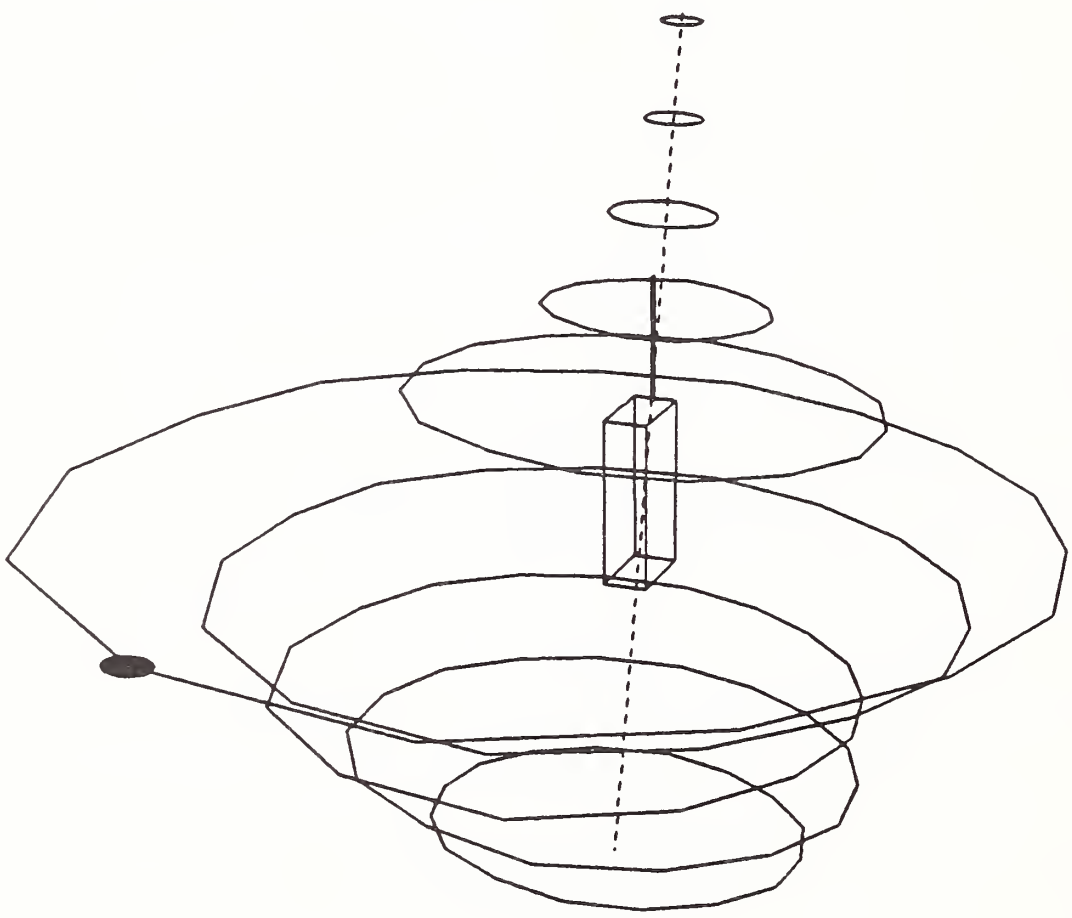

Figure 35. Three-dimensional plot of magnitude of electric field around transceiver C464 (464 MHz) measured on ground screen -- compare with figure 28 which was measured in anechoic chamber. Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 12). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

B464
RADIUS = 7
NUMBER OF POINTS = 100
● - MAXIMUM POINT: 158.82 104.40

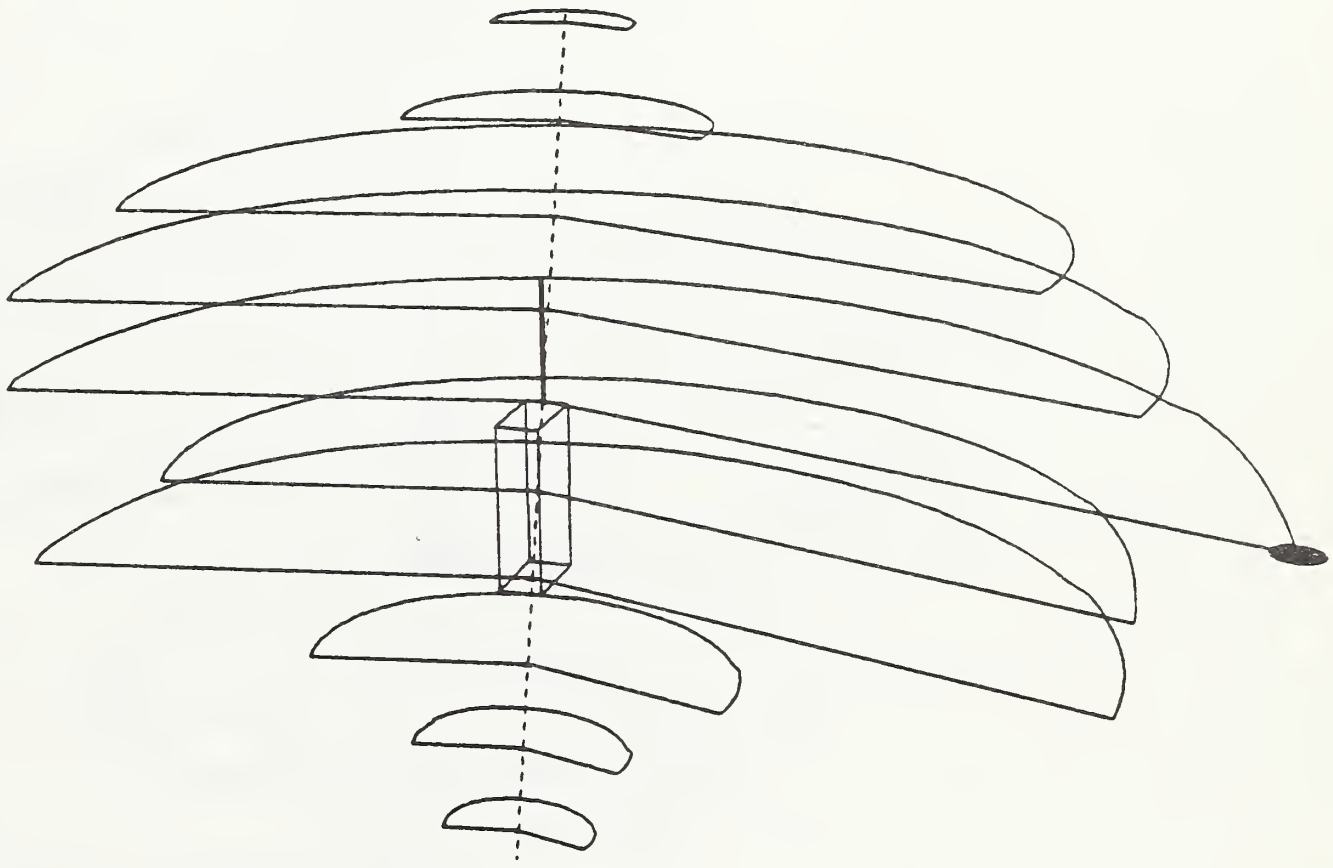

Figure 36. Three-dimensional plot of magnitude of electric field around transceiver B464 (464 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 7). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

B464
RADIUS = 12
NUMBER OF POINTS = 50
● = MAXIMUM POINT: 82.22 151.20

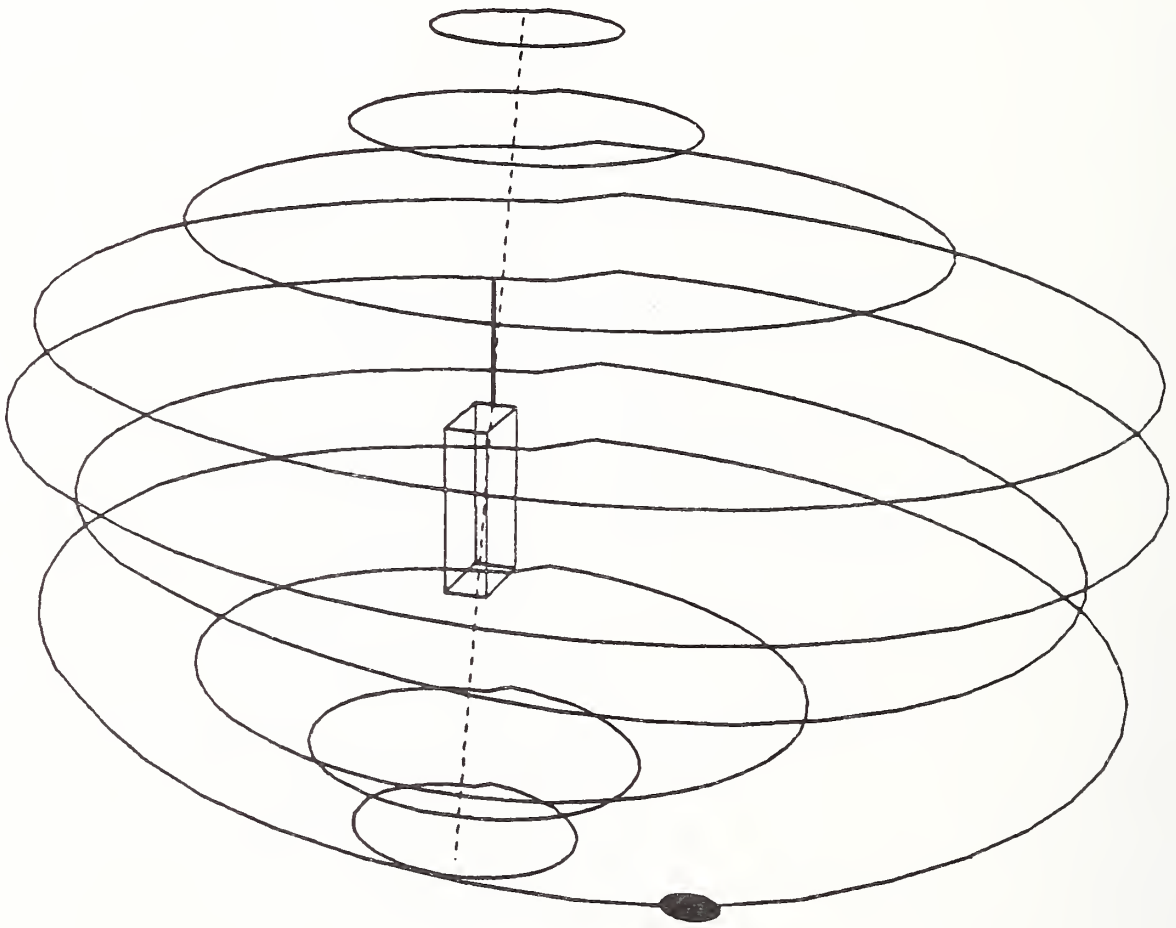

Figure 37. Three-dimensional plot of magnitude of electric field around transceiver B464 (464 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 12). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

A823

RADIUS = 7

NUMBER OF POINTS = 100

● - MAXIMUM POINT: 88.96 -108.00

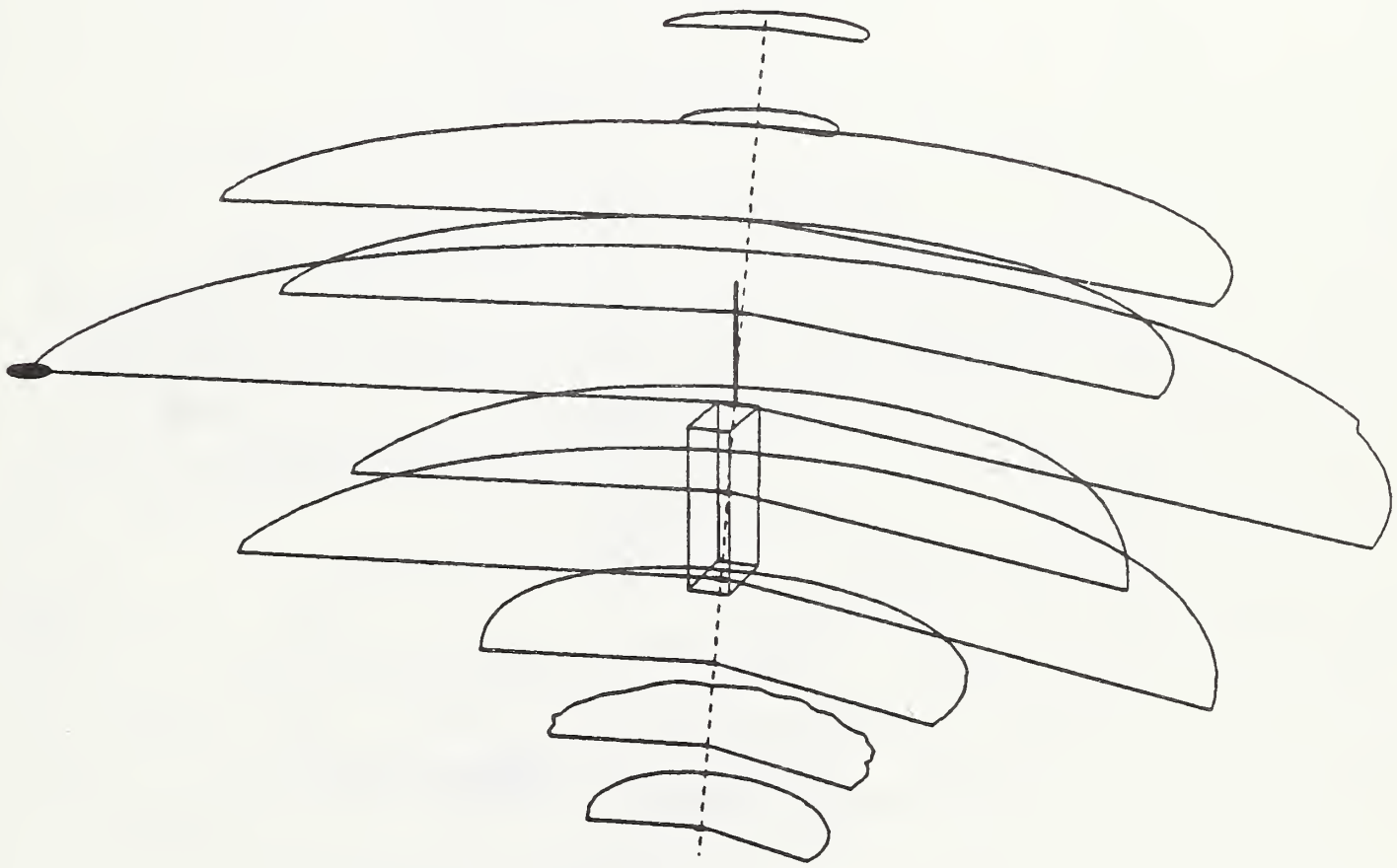

Figure 38. Three-dimensional plot of magnitude of electric field around transceiver A823 (823 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 7). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

A823
RADIUS = 12
NUMBER OF POINTS = 50
● = MAXIMUM POINT: 56.70 158.40

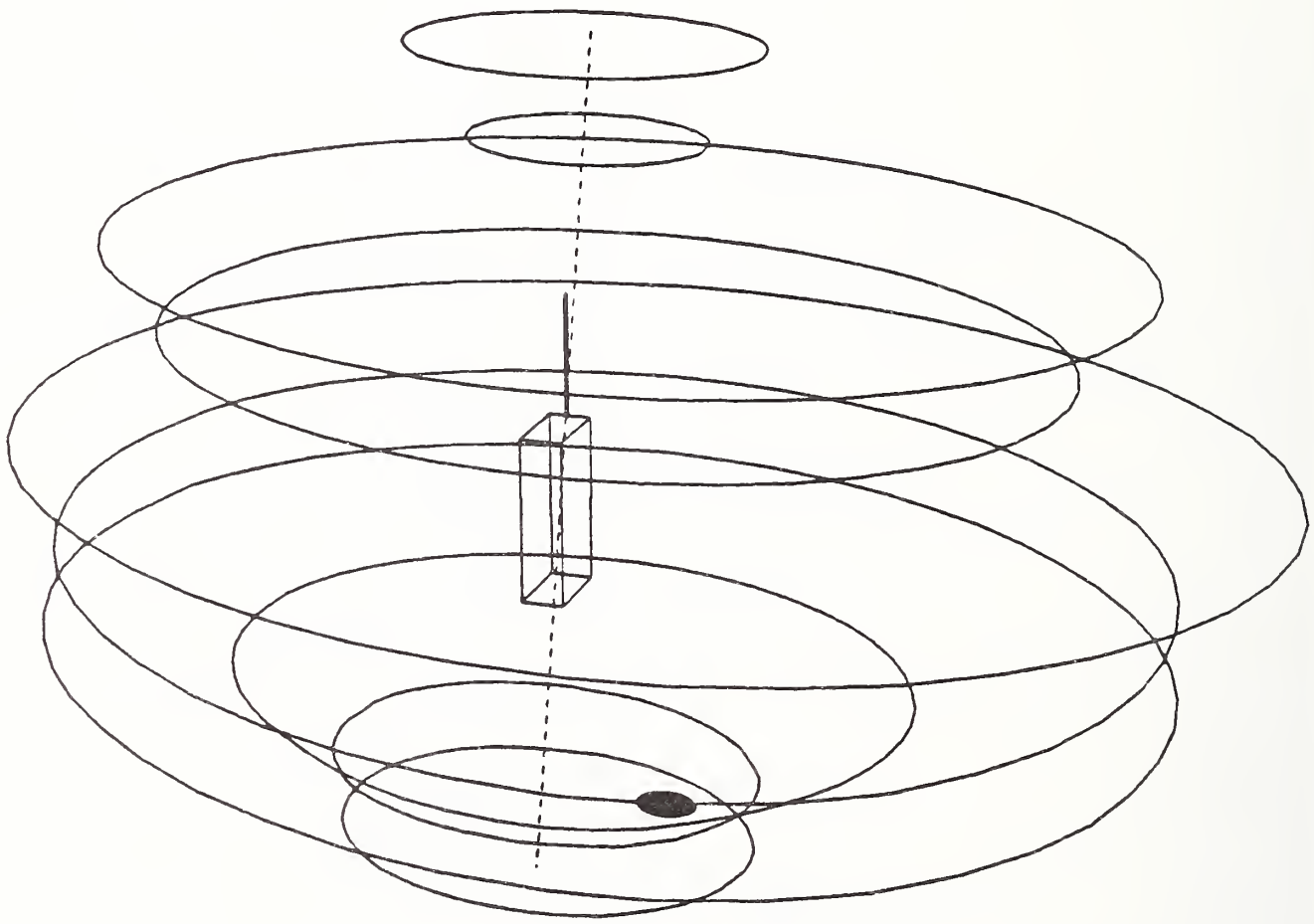

Figure 39. Three-dimensional plot of magnitude of electric field around transceiver A823 (823 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 12). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

B823
RADIUS = 7
NUMBER OF POINTS = 100
● = MAXIMUM POINT: 157.69 -28.80

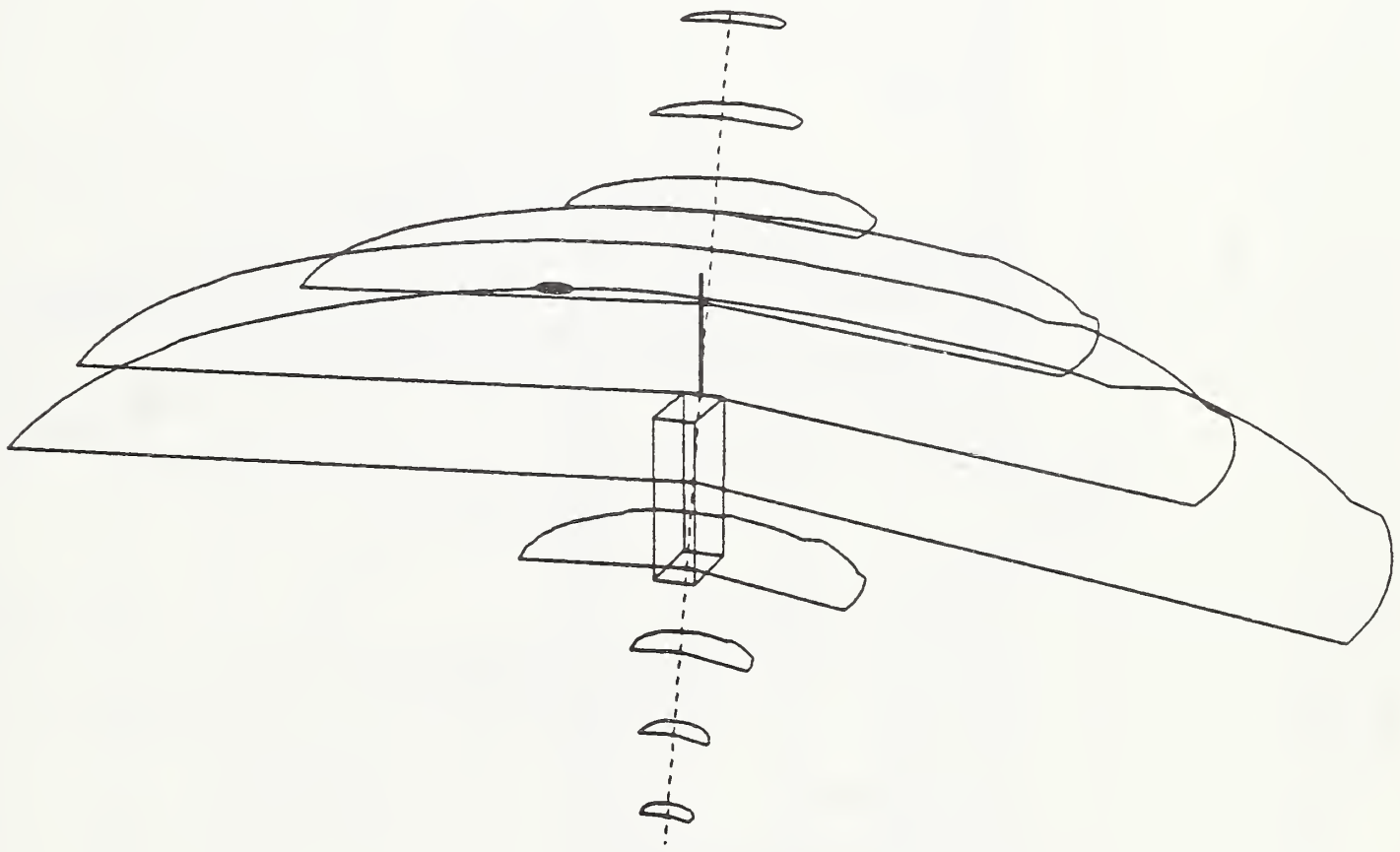

Figure 40. Three-dimensional plot of magnitude of electric field around transceiver B823 (823 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 7). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

B823
RADIUS = 12
NUMBER OF POINTS = 50
● = MAXIMUM POINT: 95.00 72.00

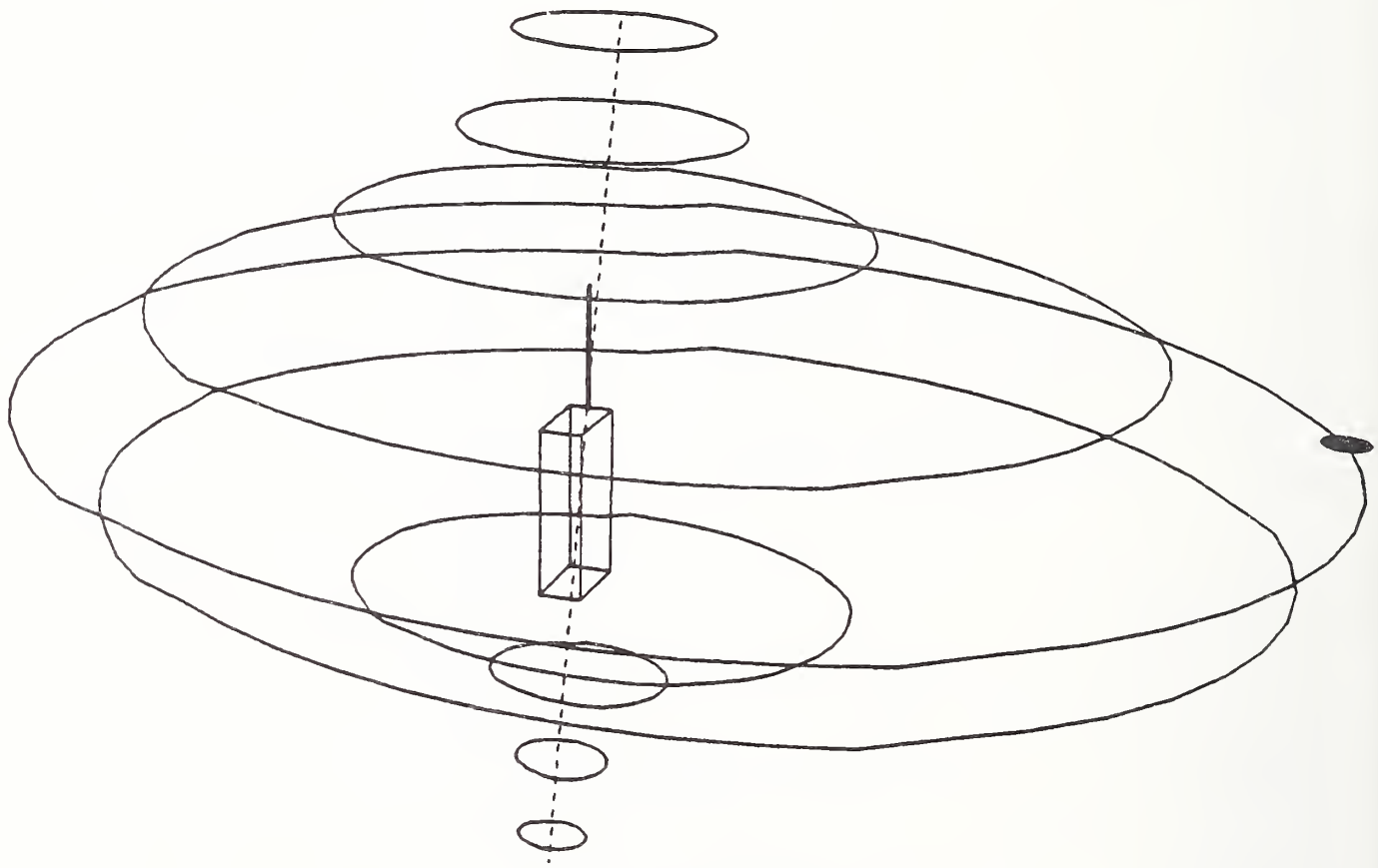

Figure 41. Three-dimensional plot of magnitude of electric field around transceiver B823 (823 MHz). Radii of disks are proportional to magnitude of electric field. Separation distance between transceiver antenna and probes is in centimeters (RADIUS = 12). Maximum value of field strength is marked with black dot. The two numbers after MAXIMUM POINT are electric field strength in volts per meter and angle of rotation in degrees.

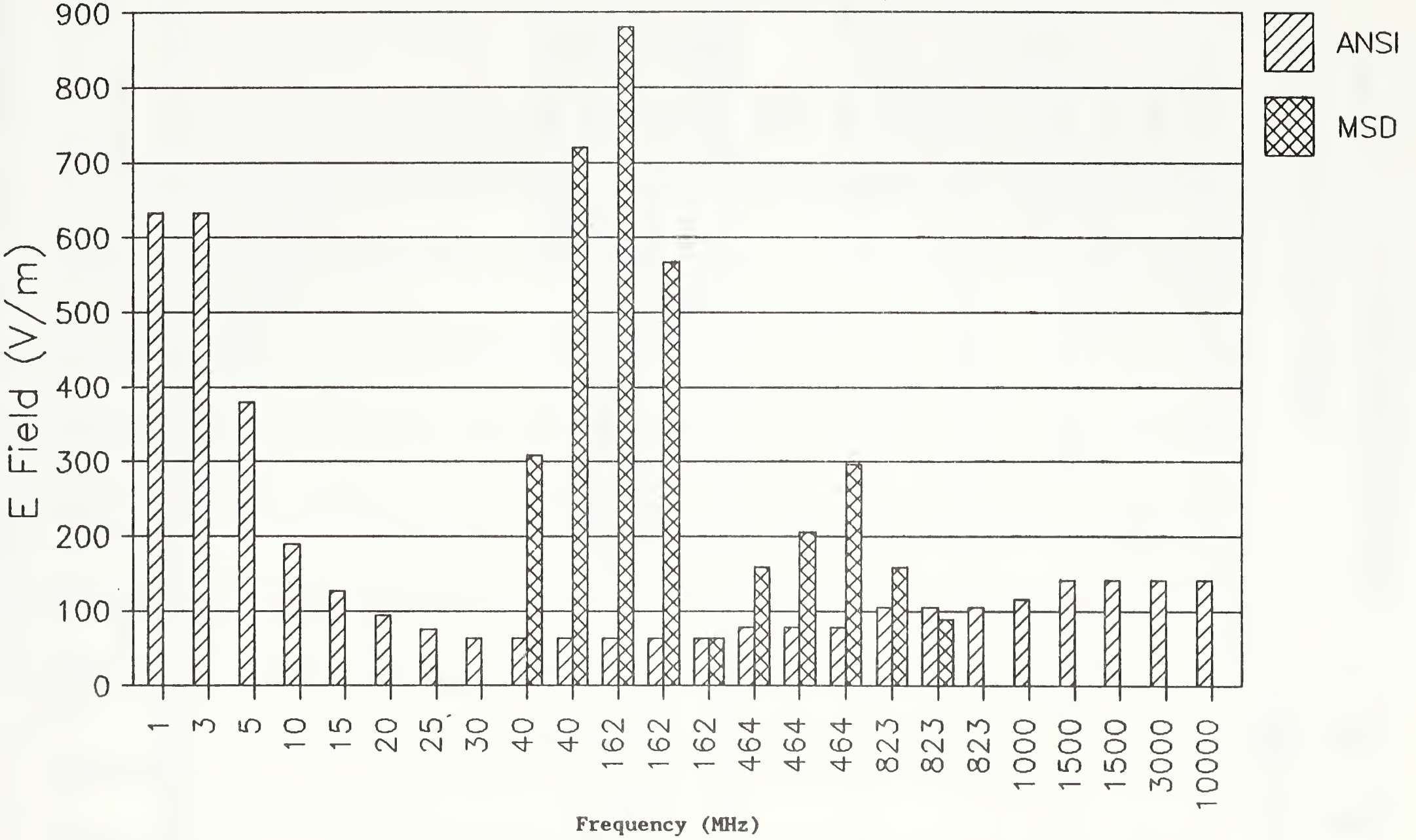

Figure 42. Comparison of maximum measured values of electric field strength with limit from ANSI C95.1-1982, Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields.

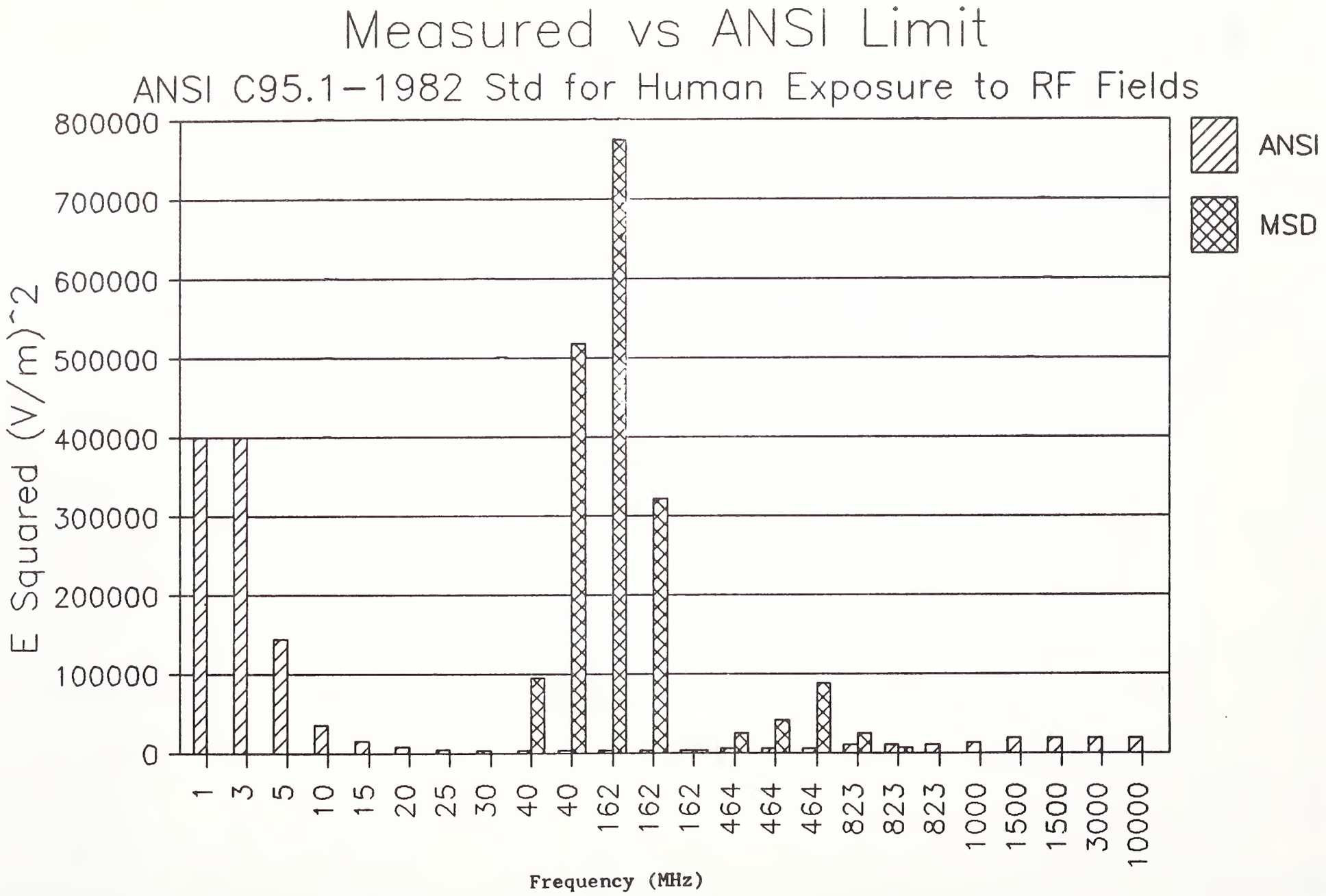

Figure 43. Comparison of the square of E field (proportional to power density) calculated from maximum measured values of electric field strength with limit from ANSI C95.1-1982, Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields.

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11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

Electric field strengths were measured at a number of points near 5-W personal transceivers. The points were located on cylinders of revolution around the antenna with radii of 7, 9.5, 12, 14.5, 17, and, in some cases, 27, 37, and 47 cm. At shorter distances, these measured values exceeded the exposure limits suggested in ANSI Standard C95.1-1982.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

electric field measurements; personal transceivers; walkie-talkies

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